VOLTAGE AMPLIFICATION CURVES

OF

AUDIO FREQUENCY TRANSFORMERS

A THESIS

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It is proposed to discuss in this thesis (a) the principles involved and the results desired, (b) the method of measuring voltage amplification, and (c) the results actually obtained, in using transformers for inter-stage coupling devices in audio frequency amplifiers.

(a) The Principles Involved and the Results Desired.

Several schemes are used to couple successive stages of radio amplifiers in which it is desired to increase the amplitude of the current and voltage variations whether these variations be at frequencies to which the ear is sensitive, called audio frequencies, or at frequencies, called radio frequencies, above those to which the ear responds. It is proposed here, however, to discuss only those factors influencing the amplification of audio frequency signals by means of transformers; in a later section will be shown how manufacturers have coped with these factors in so far as I have been able to determine from tests on a majority of the transformers which are now, or have been, manufactured.

The proportioning, theoretically, of the factors which are known to affect the characteristics of a transformer is settled once the ideal characteristic is agreed upon. However, much disagreement is apparent among manufacturers regarding this ideal, judging from sales propaganda, unless the characteristics which a manufacturer obtains in his, say, experimentally designed transformer biases his judgment. Also even if a manufacturer decides that his transformer product shall have a certain characteristic, technical or economic conditions may cause the actual characteristic to depart greatly from his, or a mutually-agreed-upon, ideal.

I will give here what I believe is a general view of the requirements for audio amplification dovetailed as it is with all of the other characteristics of broadcasting and receiving apparatus. Some of the considerations, upon which some manufacturers base their sales appeal in regard to their real or advertised transformer characteristics, will be dealt with, from my point of view and from theirs, in part (c).

Consider, first, the limitation of the human ear. Those with the best of ears can hear sounds of frequencies ranging from 16 to 20000 cycles per second. Few, however, can hear sounds to both limits, the average person not hearing easily frequencies above 10000 cycles. The range of frequency on the piano which represents the upper extreme, considering fundamental frequencies, is from 27 to 4096 cycles. Natural reproduction as far as the human ear can determine will be effected if a reproducing system will respond to its fundamental frequency and at most up to its fifth harmonic on low frequencies and only to the second harmonic at frequencies in the neighborhood of the highest frequency of the piano - 4096 cycles. Only a very few instruments, such as some pipe organs, will go as low as 16 cycles thus indicating that our audio frequency range ideally should extend, say, from 16 to not over 10000 cycles.

As mentioned above, the ear responds to only a limited range of frequencies. It is also true that human ears respond to frequencies of the same energy in the neighborhood of 1000 cycles better than to any others. This being true, it is necessary in music to compensate for this if balanced music means equal energy content for all frequencies. However, the music or other sounds that emerge from the speaker should be of similar wave form as those impressed upon the microphone. Then, whatever our musical tastes as to the relative energies at the various frequencies, if the energy amplification or transformation is uniform at all frequencies from microphone to loud speaker, we shall get from the loud speaker sound waves of the same relative intensity at the different frequencies as those that impinge on the microphone.

Practical perfection in the devices or apparatus used in transmitting and receiving music may be obtained if sufficient engineering skill is applied to their design and manufacture. Progress has been rapid in this respect, the ultimate development being, in my opinion, perfection in each unit of transmitting and receiving apparatus from the microphone to the loud speaker. If compensation for the defect of one unit is resorted to in the design of another unit, this makes for lack of flexibility of apparatus and hence is undesirable. At any rate compensation may be localized to a unit and perfection of units worked for.

Assuming that perfection in all apparatus used in transmitting and receiving sound waves will soon be closely attained, if it has not already, it follows that the audio frequency transformer as a coupling device should amplify signal intensities at all frequencies equally, and this investigation is to show, as far as possible how this has been obtained up to the present and to draw "inconclusive" conclusions as to what we may expect by way of perfection from audio frequency transformers.

Maximum energy or amplification power is obtained from a vacuum tube when the external plate circuit impedance is equal to the resistance of the tube R_p, this resistance being the reciprocal of the slope of plate current plate voltage characteristic of the tube at the point at which the tube is operated.

Neglecting for the moment any distributed capacity that the windings of a transformer may have, and assuming that all amplifier tube grids have sufficient negative potential to prevent convection currents between filaments and grids, the impedance of the transformer primary is the impedance which should be equal then to R_p. The primary impedance however is constant at only one frequency so that maximum energy amplification is obtainable at only one frequency. Using a tube, then, as a power amplifier would not give equal energy amplification at all frequencies unless Z_o is, or acts as, resistance only and is independent of the frequency.

Now consider the use of the vacuum tube as a voltage amplifier, under the assumptions above, so that its grid is maintained sufficiently negative with respect to the filament to prevent a convection current from grid to filament and that the impedance in the plate circuit is sufficiently high to make the e_g, I_p characteristic substantially linear over the operating range of input voltage. These conditions can be very nearly attained in practice even when the constants of the circuits employed are so adjusted to give maximum voltage amplification.

If an alternating voltage e_g is applied to the grid of the tube of Fig. 1 page 9 , the pulsating current i_p flowing in the plate circuit is $\frac{\mu e_g}{R_p+Z_o}$, where μ is the maximum voltage amplification obtainable from the tube, R_p is the tube resistance, and Z_o is the plate load impedance. The alternating voltage developed in Z_o is

$$e_o = i_p Z_o = \frac{\mu e_g Z_o}{R_p + Z_o} \quad . \qquad (1)$$

The voltage amplification μ' is therefore

$$\mu' = \frac{e_o}{e_g} = \frac{\mu Z_o}{R_p+Z} \quad . \qquad (2)$$

Evidently μ' increases as Z_o is increased and approaches the maximum possible amplification μ.

The plate load impedance may be either resistance or largely reactance . Let us consider then the cases (a) when Z_o is resistance only and (b) when Z_o is reactance only. The voltage amplification in the first case is

$$\mu' = \frac{e_o}{e_g} = \frac{\mu R_o}{R_p+ R_o} \qquad (3)$$

and in the second case is

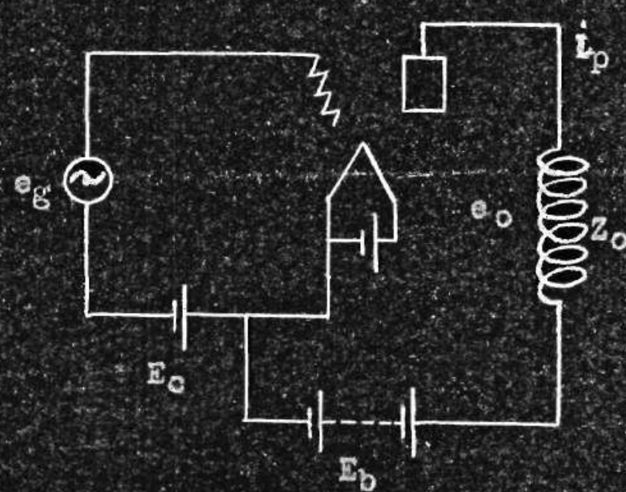

i_p
e_g
e_o
Z_o
E_c
E_b

Fig. 1

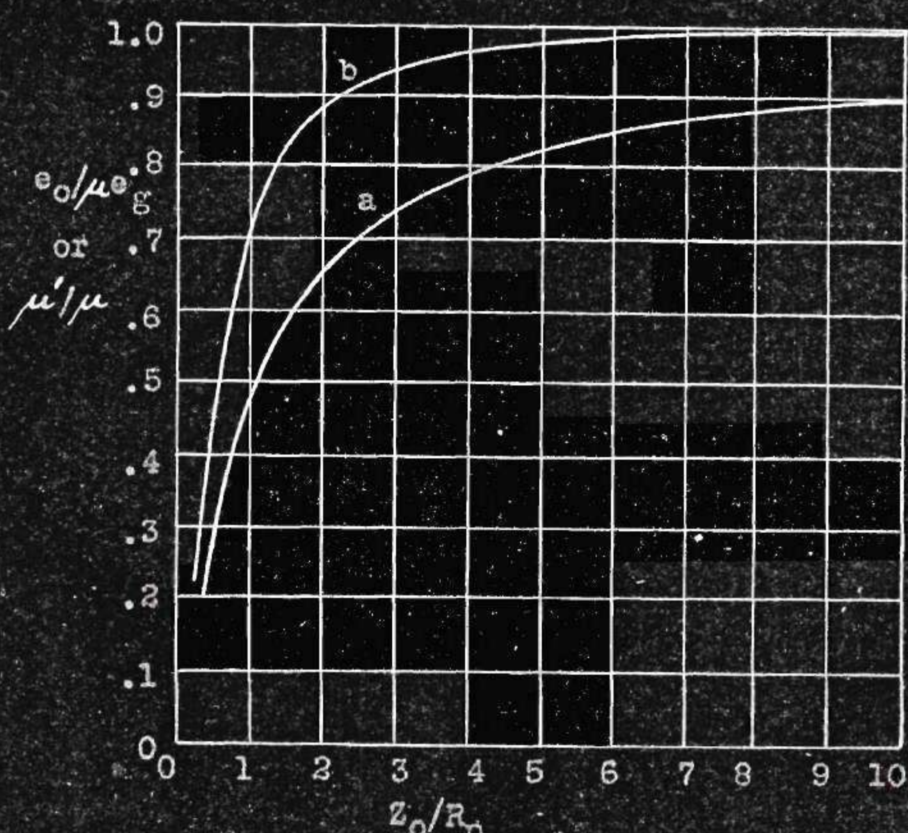

1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
e_o/μe_g
or
μ'/μ
b
a
0 1 2 3 4 5 6 7 8 9 10
Z_o/R_p

Fig. 2

$$\mu' = \frac{\mu X_o}{R_p + X_o} = \frac{\mu X_o}{\sqrt{R_p^2 + X_o^2}} \tag{4}$$

The maximum value of the ratio $e_o/\mu e_g$ for either case is unity. Curves a and b Fig. 2, page 9, show respectively for resistance only, and for reactance only, the ratio of $\frac{e_o}{\mu e_g} = \frac{\mu'}{\mu}$ that is, the proportion of possible voltage amplification obtainable from a tube at different ratios of Z_o/R_p where Z_o is R_o in the first case and X_o in the second. Relative values only are necessary in computing these curves. It is seen that the ratio $e_o/\mu e_g$ reaches about .9 or 90 per cent of its maximum value when $R_o = 10R_p$ or when $X_o = 2R_p$, and that for values of R_o and X_o above those which give 90 per cent of maximum voltage amplification, the curves rise slowly.

Therefore if we use a transformer the primary of which is connected in the plate circuit of a vacuum tube and which is considered to have a comparatively small resistance and a reactance which is at least two times the plate resistance of the tube we are using at the lowest frequency we wish to amplify, the voltage across the primary will not be more than 10 per cent greater at any frequency higher than that for which $X_o = 2R_p$; under these conditions the voltage amplification will depend upon the frequency, so far as it has been considered, to only a small extent and will be independent of the frequency as far as voltage step-up in the transformer is concerned.

Distortion may occur in the wave form of the voltage before or after it reaches an amplifier tube due to the mechanical characteristics of an air column and the micro-phone diaphragm and its arrangement; to the fact that carbon does not give a linear pressure-resistance relation if a carbon granule microphone is used; to the cutting of carrier wave side bands; to tube distortion; to over-modulation; to poor coupling and circuit characteristics; to detection or demodulation difficulties; and to the difficulties encountered in transforming current variations into like sound variations. Most of these causes of distortion may be obviated or minimized before a voltage wave is impressed on an amplifier; the amplifier then should in itself add no distortion. In the circuit in which the loud speaker or telephones are located, however, it is desired that sound variations shall be proportionally produced by the current variations. It is necessary then in this case to make the last tube a power amplifier tube, but as has been pointed out, maximum power amplification is obtained from a tube at only one frequency- that frequency at which the load impedance is equal to the resistance of the tube itself. This means that even if the loud speaker, for example, transformed all current variations into sound variations of similar form, distortion nevertheless occurs unless the plate load impedance is made equal to the resistance of the tube and practically independent of the frequency. This is usually only approximately done but even if not, no marked change in effect on the ear results by the use of one stage of power amplification, if the tube load impedance does not range more than from about one-half to two and one-half times the tube resistance. The use of a power tube in the last stage obviates a distortion which might result if large voltage variations are impressed on the grid of a tube, used in the last stage, which has an $e_g i_p$ operating characteristic which is not linear over the whole operating range; it is desirable in this respect.

Considering then that it is desirable to use a vacuum tube as a voltage amplifier, a review of other factors which may affect voltage amplification in an amplifier of this kind will be undertaken.

The part that the distributed capacity of a transformer plays may be of great importance in determining its characteristic when associated with an amplifier tube. This distributed capacity may be considered as consisting of, first, the sum of the capacities between two adjacent turns all connected in series from one terminal of the winding to the other; second, the sum of the capacities in series between adjacent layers; third, the sum of the capacities between the windings and the core and other metals in the neighborhood; and fourth, the electrode capacities. These capacities may be considered in terms of their equivalent values as connected across or to the winding terminals as shown in Fig. 3, page 14. Of these parts the first and fourth are usually comparatively small since in the first case it consists of a large number of small capacities in series, and in the second case it consists of the tube inter-element capacities and connecting leads capacities which will have a total capacity ordinarily of only a few micro-micro-farads. The second part is of importance depending upon the number of layers - decreasing with the number of layers - and the separation between them. The third part is usually the most important since it seldom consists of more than two capacities in series. Fig. 3, page 14, shows schematically an equivalent circuit of an amplifier tube and its associated apparatus. C_1 and C_2 represent the series capacities of the turns and layers of the primary and secondary windings respectively. C_3 represents the equivalent capacity between windings, C_4 and C_5 the capacities to the transformer core respectively of the primary and secondary windings, and C_6, C_7, C_8, and C_9, the usually small inter-electrode capacities.

The electrostatic fields existing so overlap that the definite exact placement of all equivalent lumped capacities is impossible. The composite capacities act, however, as tho they were shunted across the primary and secondary windings in most cases since the charging currents diminish the windings proper. Thus we may substitute the assumed equivalent circuit of Fig. 4, page 14, for that of Fig. 3 on this page.

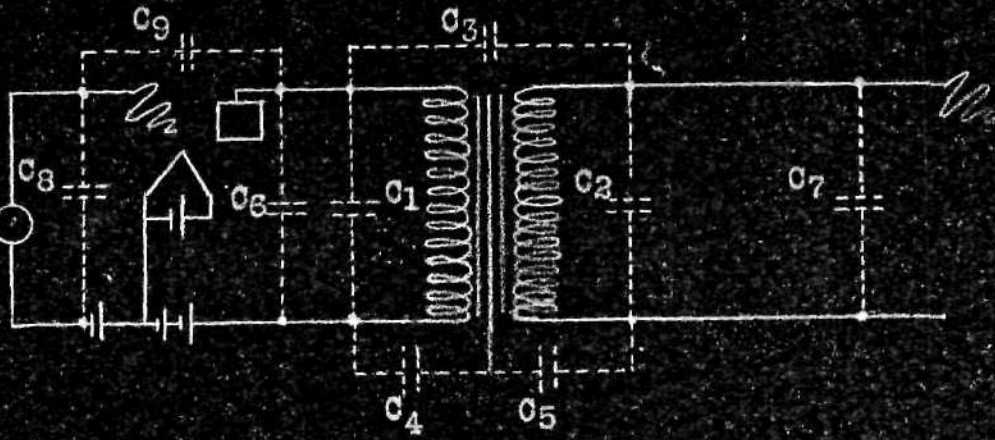


Fig. 3

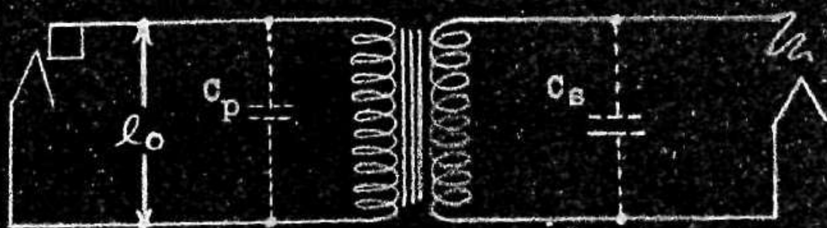


Fig. 4

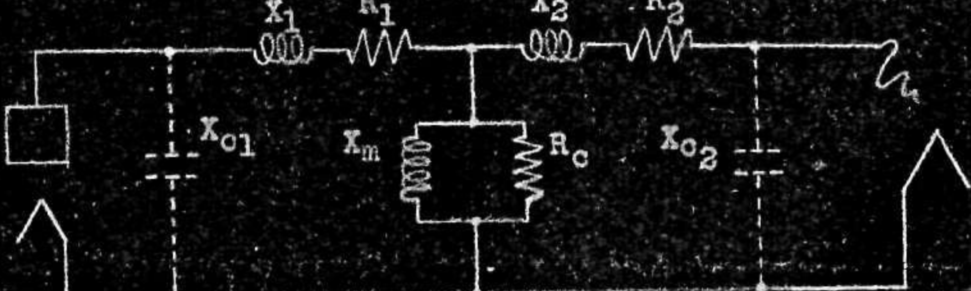


Fig. 5

As was seen above the voltage developed in the output circuit of a vacuum tube depends upon the load impedance; this impedance at any frequency will be made up of the total equivalent primary impedance if a transformer is used with its primary connected in the plate circuit. The load on the transformer itself will consist of the equivalent distributed capacity of its secondary. Fig. 5 shows the equivalent circuit of a transformer when all impedances are referred to the primary. The equivalent reactances X_{C_1} and X_{C_2} represent the reactances of the primary and secondary distributed capacities respectively reduced to primary values; X_1 and R_1 represent respectively the leakage reactance and resistance of the primary; X_m is such that it takes a current equal to the magnetizing current of the transformer; R_c is such that the power absorbed in it is equivalent to the core loss in the iron, consisting of the hysteresis and eddy current losses; and X_2 and R_2 represent, respectively, the leakage reactance and the resistance of the secondary. All secondary equivalent values as shown in the primary are considered as having been divided by the square of the ratio of secondary to primary turns to reduce them to primary values.

Now the resistances of both primary and secondary will be negligible compared to their inductances ordinarily; for good design the leakage reactances X_1 and X_2 will be small as will the losses due to hysteresis and eddy currents. Under these assumptions we have for the equivalent circuit of a transformer that shown as Fig. 6, page 16, in so far as

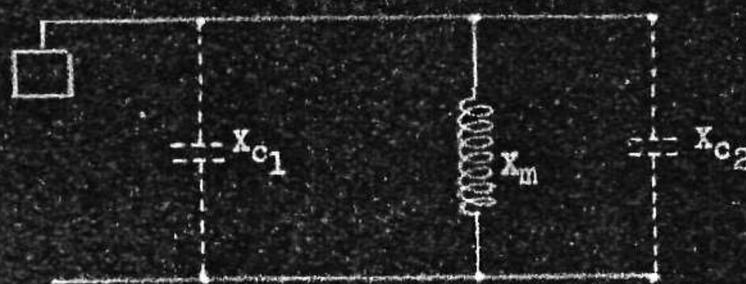


Fig. 6

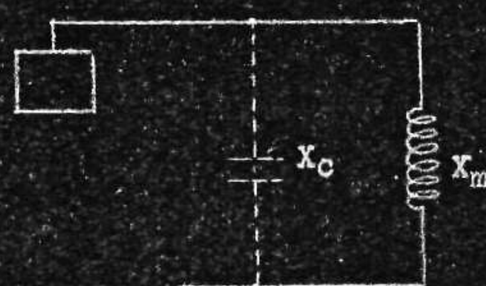


Fig. 7

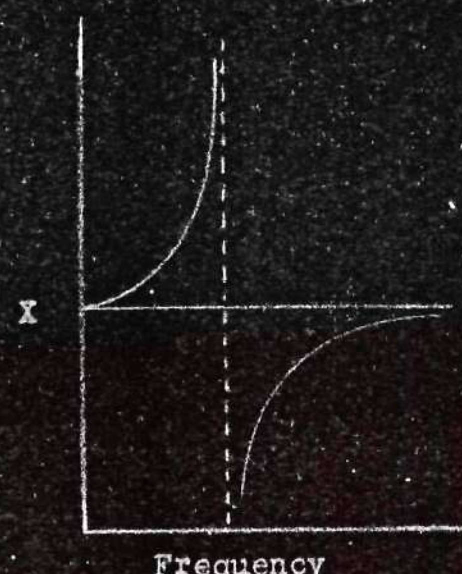


Fig. 8

determining simply the load in the plate circuit is concerned. Thus the voltage amplification obtained from the tube proper will depend closely upon the impedance of the three branches in parallel. However X_{C_2} may be combined with X_{C_1}, giving a parallel circuit of two branches, one branch of which is capacitive and the other of which is inductive, as shown in Fig. 7, page 16 . According to the behavior of such a parallel circuit we have an impedance which will rise from zero at zero frequency, to a maximum, which is theoretically when the frequency is such, called the resonant frequency, that the reactances of the two branches are equal, and will then drop to zero at infinitely high frequencies as depicted in Fig. 8, page 16 . Resistance in the circuit branches prevents the impedance from either becoming zero at zero frequency or infinite at the resonant frequency, however. Since the voltage amplification will vary markedly if the load in its plate circuit has an impedance which falls below $2R_p$, a tube when used as a voltage amplifier should have an impedance of $2R_p$ thruout a range of about 30 to 8000 cycles. If then the impedance branches as shown in Fig. 7, page 16, have a total impedance which is equal to or more than $2R_p$ from about 30 to 8000 cycles, the voltage across the primary of the transformer will be 90 per cent or more of its maximum value. As for the voltage in the secondary , it depends not only upon the voltage across the primary but also upon the transformer voltage step-up ratio and the fact that the secondary may show series resonance effects. The limiting factors which will then determine whether the load in the plate circuit of a tube is twice, at least, as large as the tube resistance, will be the inductance of the primary at the low frequencies and the equivalent primary distributed capacity of the transformer at the frequencies in the neighborhood of 8000 cycles.

Assuming that the resistance of the tube with which a transformer is used is 12000 ohms, this being the average value of the resistance for a UX201A type tube with a plate battery voltage E_B and a grid battery voltage E_C of 90 and -4.5 respectively, we find that if the primary inductance is to be such that its reactance is 2 x 12000 = 24000 ohms at 30 cycles, then its inductance in henries would be

$$L_p = \frac{X_p}{2\pi f} = \frac{24000}{2\pi 30} = \frac{400}{\pi} = 127 \text{ henries.}$$

Since the reactances of the secondary are converted into equivalent primary reactances by dividing by the square of the ratio of voltage transformation, approximately, then the effect of secondary distributed capacity C_2 is r^2C_2 across the primary, where r is the ratio of transformation. If the capacity of the primary was transferred to the secondary its effect in the secondary would be C_1/r^2. Secondary distributed capacity, therefore, will affect to a great extent the tube load impedance, if it exists in even small amounts compared to a primary capacity which affects it, and its effect will be the greater as the ratio is increased. The effect of primary capacity in the secondary in affecting resonance will, however, be small.

If the distributed capacity of the secondary of a transformer is great enough it may be resonant within the audio range. In this case we will have series resonance and the voltage across the secondary may be many times the induced voltage, as in the case of all series resonant circuits. The induced voltage will depend upon the equivalent plate circuit load and the ratio of transformation of the transformer. The voltage across the secondary will be

$$E_c = \frac{E}{2\pi f CR} \qquad (5)$$

where E is the induced voltage , f is the frequency of resonance, C is the total secondary equivalent capacity of the transformer, and R is the equivalent effective resistance. Thus if the denominator is less than unity, the output voltage may be greater than E. The sharpness of resonance will depend, of course, upon the value of $1/2\pi fCR$ or $2\pi fL/R$, L being the equivalent transformer secondary inductance. If resonance is made to occur where the voltage amplification curve would otherwise have a falling characteristics below 8000 cycles it may be an advantage; if resonance occurs where the curve would otherwise be flat, then resonance will cause distortion in this case. It should be noted that sharpness of resonance will be according to octaves on the three section semi-logarithm paper which will be used to plot the curves obtained.

Other factors which affect the shape of the curves, such as the relative proportioning of the number of turns to the character and amount of iron used in a transformer core, hysteresis and eddy-current losses, the effect of using tubes of various resistances, the effect of the use of different points of operation on the magnetization curve of the transformer , the effect of poling the transformers, etc., will be discussed with regard to the curves under Part (c).

(b) The Method of Measuring Voltage Amplification

Briefly, the method was to apply a constant voltage at frequencies ranging from 60 to 10000 cycles to an amplifier tube in the plate circuit of which was the primary of the transformer under test, measuring the input and output voltages by means of a vacuum tube voltmeter.

The sources of voltage were the 110 volt 60 cycle lighting mains in the laboratory and an American Telephone and Telegraph Company, 8A, vacuum tube oscillator, the frequency range of which is from 100 to 50000 cycles. The diagram of the oscillator is shown as Fig. 9 on page 22.

The maximum variation of frequency from calibrated frequency for this oscillator is 1 per cent and for small outputs within the voice range the wave output is practically free of harmonics. The 60 cycle lighting main supply was found to be practically sinusoidal when checked by a visual oscillogram, and thus the voltage amplification obtained with it as a source of voltage to the amplifier gave points which fitted in with the amplification curve points at immediately higher frequencies in practically every instance. Lower sources of voltage were available but they did not give even approximately a sinusoidal voltage; therefore the frequency range was not extended below 60 cycles.

The vacuum tube voltmeter arrangement is shown on

OSCILLATOR

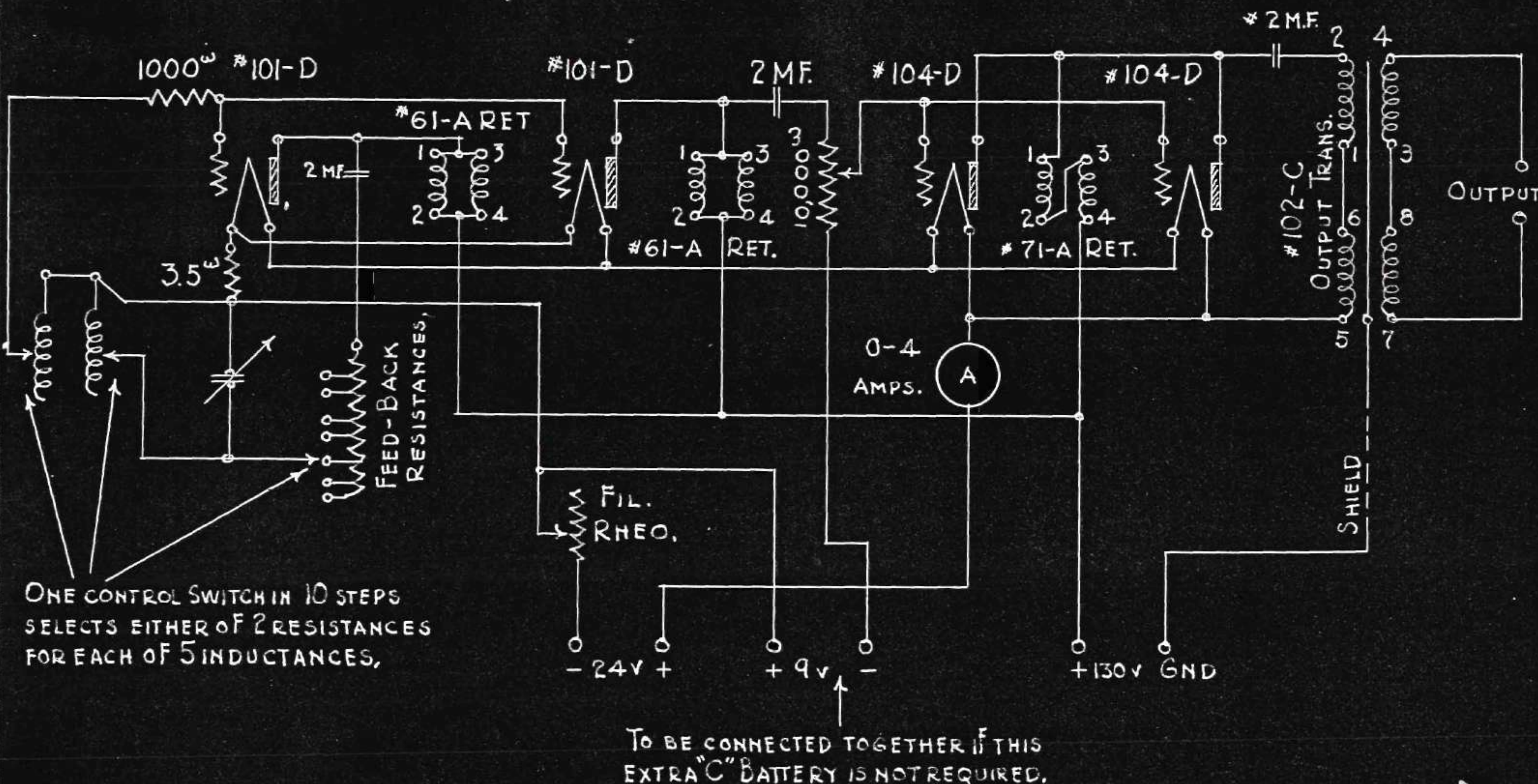


Fig. 9

page 28 as Fig. 11. Before giving a description of it, the principles involved will be reviewed. Simply put, a three electrode vacuum tube may be used as a voltmeter by impressing an alternating voltage in its grid circuit and so adjusting the grid battery potential that the variation in grid potential occurs on the lower curved position of the grid voltage current characteristic making the average plate current increase proportional to the alternating voltage impressed in the grid circuit. Grid current ceases to flow when the grid is made negative with respect to the filament by a small amount hence, if the grid is made so negative that no grid current can flow during the positive half cycle of the alternating voltage, the tube used in this manner will absorb no power from the alternating voltage source.

Referring to Fig. 10a, it is seen that if no alternating voltage is supplied by the a.c. source the normal plate current as read by the d.c. meter in the plate circuit is the steady value I_0, but as an alternating voltage is introduced in steps E_1,E_2,E_3, as shown in Fig. 10c, the plate meter reading increases to I_1, I_2, and I_3 respectively, since it reads average values. When the input voltages are large, a larger C battery is used as in Fig. 10b. Thus curves may be plotted showing the relation between effective input volts, as read by the voltmeter of Fig. 10c, and the plate current in milliamperes as shown by curves a

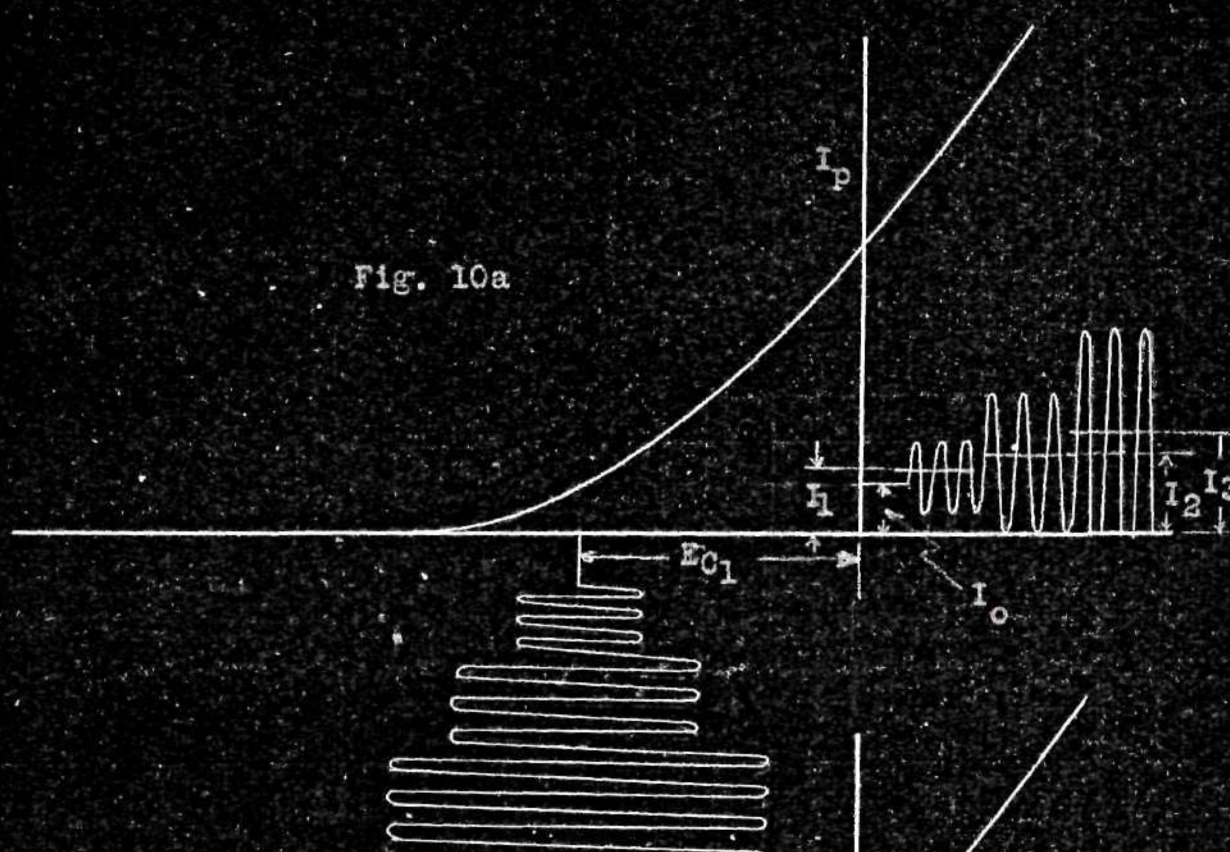


Fig. 10a

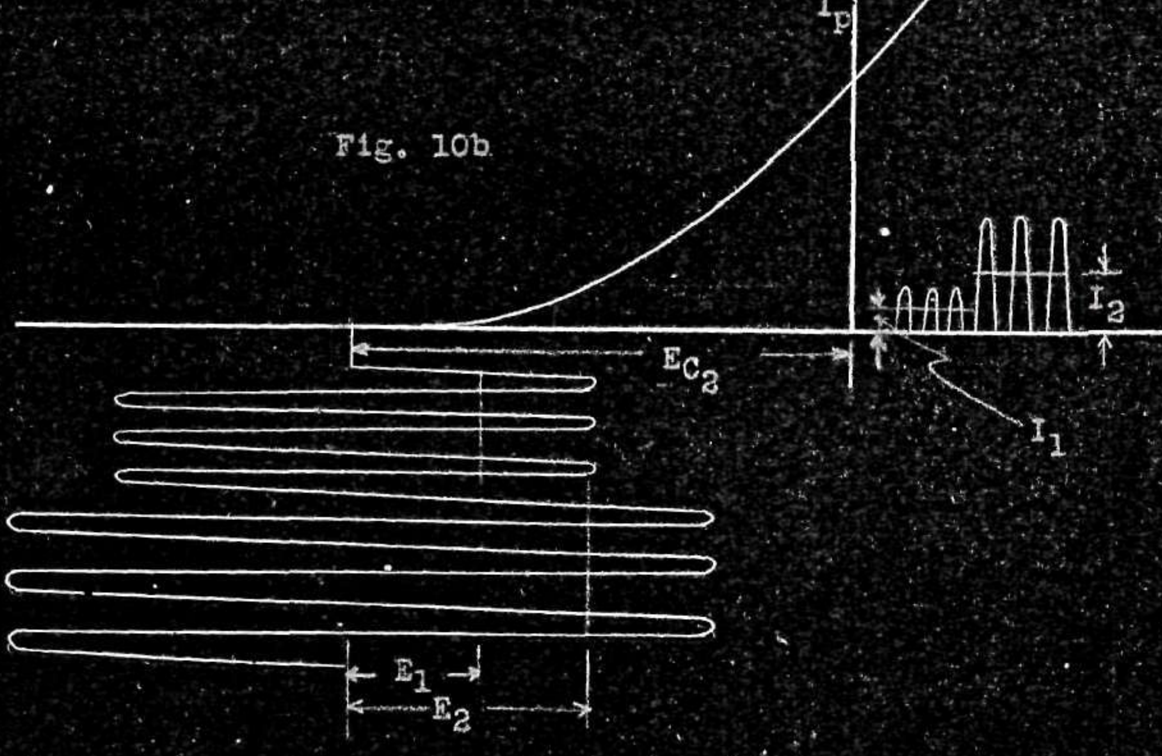


Fig. 10b

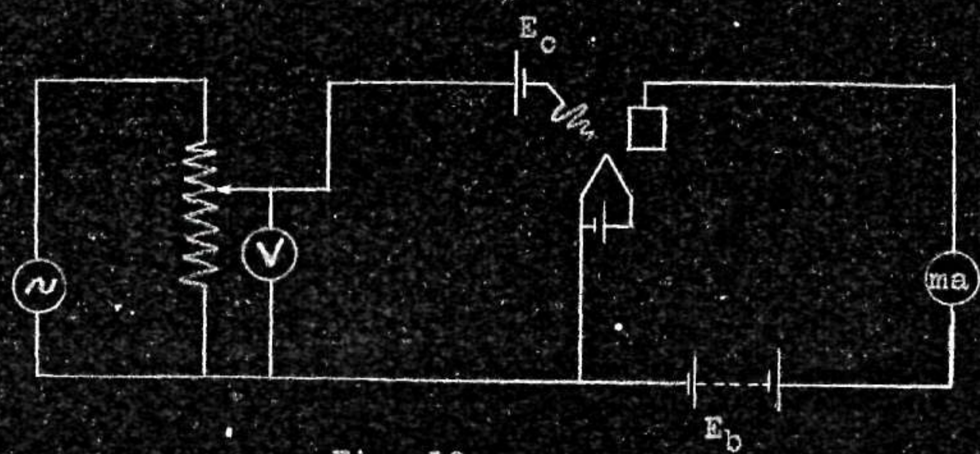


Fig. 10c

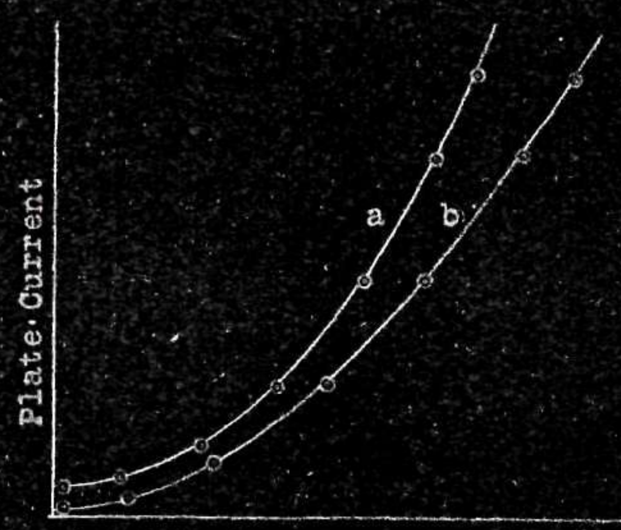


Fig. 10d

and b for different C batteries and voltage steps in Fig. 10d. Such curves representing actual values are shown on the Calibration Curve Sheets, pages 195-8. Under the conditions that no grid current flows, we may assume that the voltage to be measured by the V.T.Voltmeter was not altered when the V.T. Voltmeter was attached except in so far as the circuit was altered by the small electrode capacities of the tubes. Since these capacities are only a few micro-micro-farads, at audio frequencies they are practically negligible. The calibration is done at frequencies at which ordinary voltmeters may be used as standards and then is used independent of the frequency until the electrode capacities become of consequence which will ordinarily be at frequencies greater than 50000 cycles, depending on the character of the input impedance. Thus in shunt with a tuned radio frequency circuit, the frequency of resonance might be changed considerably but at audio frequencies, these capacities are usually negligible in effect.

It is not particularly necessary that the calibrating voltage wave form be sinusoidal as may be shown*. To a first approximation the rectified plate current varies as the square of the effective value of the applied alternating grid voltage, and to this approximation the rectified plate current is independent of wave form.

* See Moullin and Turner, Journal of I.E.E.(British)vol. 60 p. 708.

Referring to Fig. 11, page 28 , tubes VT_2 and VT_3 were two UX201A tubes acting as the voltmeter tubes and connected in parallel for increased sensitivity. In the plate circuit of these tubes were connected in series a milliammeter , ma., range 0 to 25 milliamperes, and a microammeter, range 0 to 500 microamperes, with a switch across the microammeter for short circuiting purposes. The plate voltage source, 1, for the voltmeter tubes consisted of 4 - 45 volt "extra-heavy-duty" B batteries in series, across which was connected a resistance, 2, of 35000 ohms, to maintain this voltage constant and practically independent of the vacuum tube voltmeter load fluctuations. From plates to filaments was connected a 4 microfarad condenser, 3, to keep the plate reactance low to the plate current pulsations. The filament rheostat is 4 in the diagram. The C batteries for the vacuum tube voltmeter, 5 and 6, were so arranged in conjunction with jack, 7, that the battery, 5, was normally in the grid circuit but that 6 might be thrown in by means of a solid brass plug if the output voltage of the transformer was such that the V. T. Voltmeter tube grids might take current. Thus two calibration curves for the V. T. Voltmeter were necessary - one for each battery. With 5, only V. T. Voltmeter Calibration Curves marked a on the Calibration Curves Sheets, pages 195-8 were obtained and with batteries 5 and 6 in series, Calibration Curves marked b on these pages were obtained. The voltages of the grid

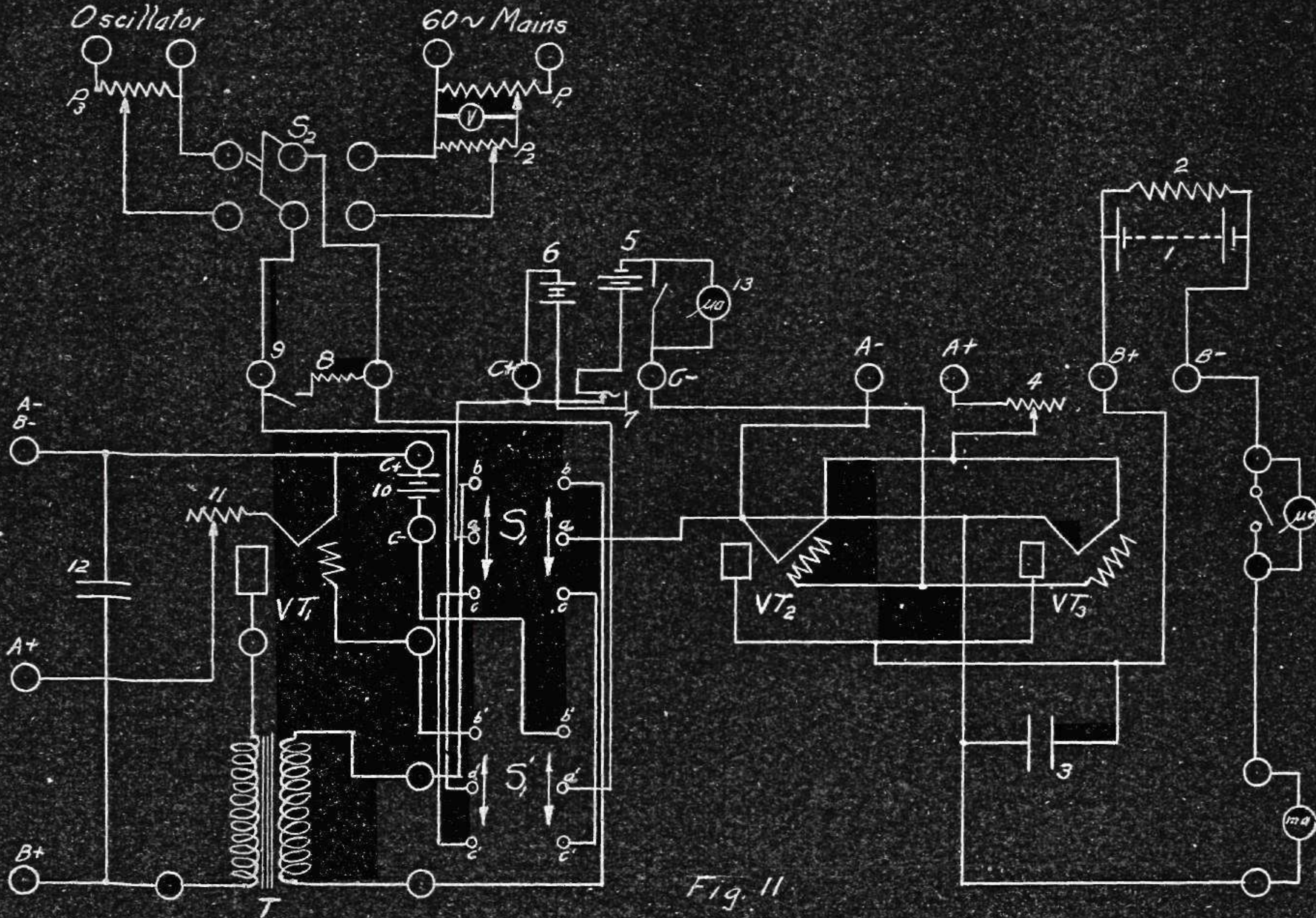

Oscillator
60~ Mains
P_3
P_1
P_2
V
S_2
6
5
13
μa
9
8
C+
G-
7
A-
A+
4
B+
B-
2
1
A-
B-
11
12
VT_1
C+
10
C-
S_1
S_1'
A+
B+
T
VT_2
VT_3
μa
3
ma

Fig. 11

and plate batteries, 5 and 1, respectively, were so adjusted, in connection with the normal voltage input to the amplifier tube of highest amplification constant and with a fairly high ratio transformer, that it was seldom necessary, to add the C battery 6 to keep the grid enough negative that it did not take current that would have been read by the microammeter, 13, temporarily used in the grid circuit. At the same time the current was decreased low enough that the steady value of the plate current with no input voltage, and the increase due to the measured voltage that it was desired to impress on the amplifier tube, could be measured by the microammeter in the plate circuit. It was found also that the plate current increase for the normal voltage input used, was affected to a very small extent by variations in the steady value of the plate current in the neighborhood of the chosen operating point. The plate and grid battery voltages found to give these results were 180 and 23.5 volts respectively.

The remainder of the diagram pertains to the operation of the apparatus as a whole and will now be described. The potientiometer P_1 is across the 110 volt 60 cycle alternating current supply; the potientiometer P_2 was the accurate resistance box of an American Telephone and Telegraph Company 14 B Bridge arranged as a potientiometer as shown in Fig. 12. The voltage across P_2 was kept constant when the vacuum tube voltmeter was being calibrated or the

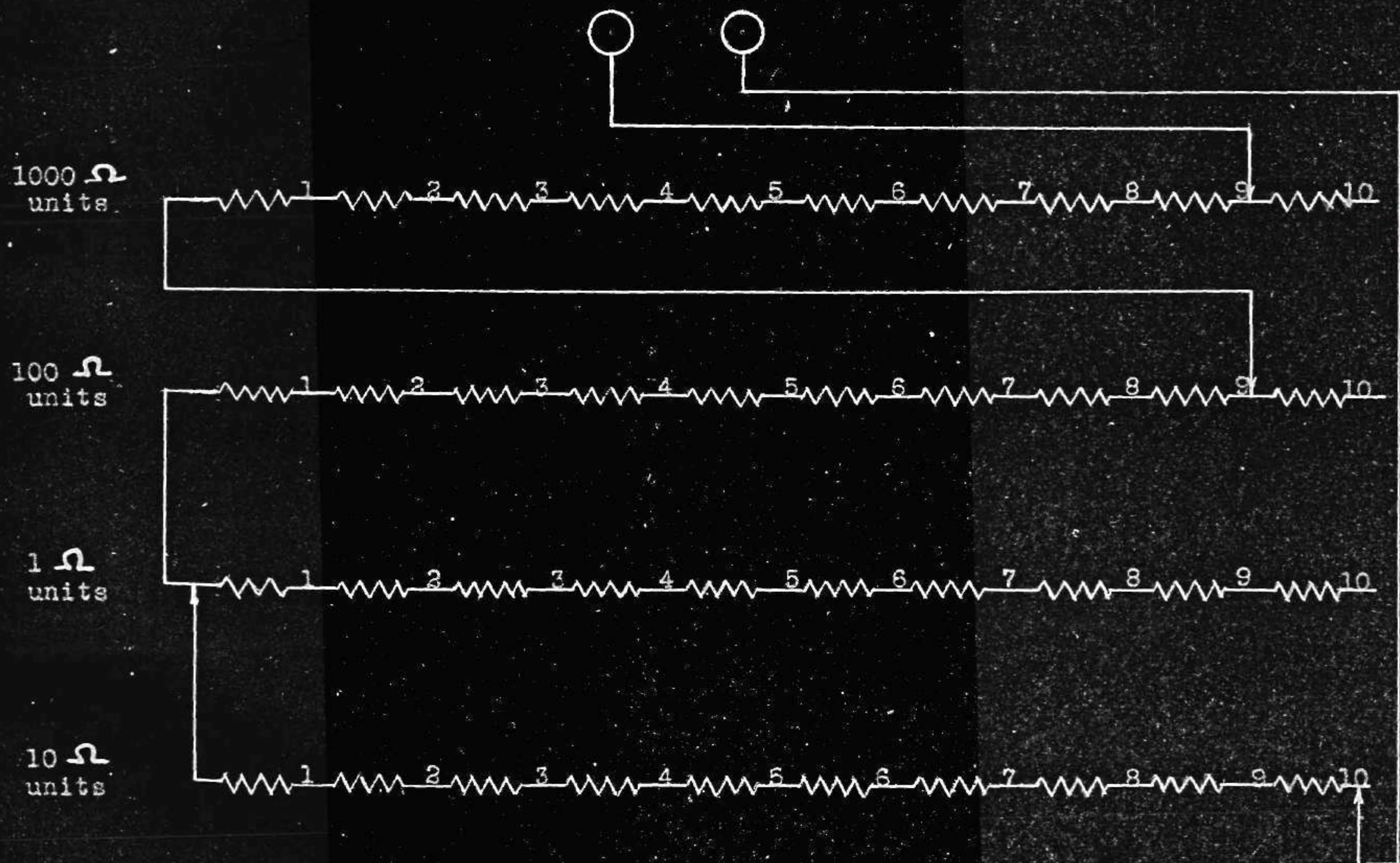

1000 Ω units
1 2 3 4 5 6 7 8 9 10
100 Ω units
1 2 3 4 5 6 7 8 9 10
1 Ω units
1 2 3 4 5 6 7 8 9 10
10 Ω units
1 2 3 4 5 6 7 8 9 10

Fig. 12

110 volt a. c. supply used as a source of input to the amplifier, by means of P_1. By using combinations of voltages and resistances in, P_2, convenient voltages could be obtained. Thus adjusting the voltage across P_2 to 100 volts and the resistance of P_2 to 10000 ohms as shown in Fig. 11, a voltage drop of .1 volt existed across each ten ohm unit and 1 volt across each 100 ohm unit. By using combinations of voltages across, and resistances in, P_2, of 50 or 100 volts and 5000 or 10000 ohms, respectively, the voltages desired were obtained.

The potientiometer P_3 across the variable frequency oscillator was used so that the oscillator output voltage might be accurately adjusted.

Switch S_2 was for the purpose of switching alternating voltage sources as desired. It was of high grade construction mounted on hard rubber.

The resistance, 8, was for the purpose of preventing the grid circuit of either the amplifier tube or the voltmeter tubes from being opened by opening the switch S_2 or disconnecting the voltage supplies. It was left in the circuit by leaving the jack switch 9 closed except when readings were being made. Its value was high - 50000 ohms - so that the input voltages would not be short circuited.

The switch S_1S_1' was a Federal "Anti-Capacity" switch of two interconnected sections, S_1 and S_1', equivalent to a four pole double throw switch. Thus when points aa were connected by means of a lever to points bb, points a'a' were connected to points b'b', points cc and points c'c' being disconnected, and when points aa were connected to points cc, points a'a' were connected to points c'c', points bb and b'b' being disconnected. Its purpose was to impress the voltage across the midpoints of switch S_2 either into the grid circuit of the amplifier tube VT_1 or into the grid circuit of the V. T. Voltmeter, depending, respectively, upon whether the contacts aa and a'a' were up or down.

VT_1 was the amplifier tube used, the rheostat, 11, was for its filament voltage control; it consisted of resistances so arranged that it was applicable for controlling the filament voltage of either 01A or 99 type tubes.

The battery, 10, was the C battery for the amplifier tube, and the plate, B, and filament, A, batteries were connected to the terminals marked A- B-, A+ and B+ at the left of the diagram (Fig. 11).

It is to be noted that one side of the 60 cycle mains was grounded and that the fixed side of the potientiometers P_1 and P_2 were connected on the filament side of switches S_2 and S_1S_1' and made the grounded side of the 60 cycle supply. The C batteries 5 and 6 of the V. T. Voltmeter were put in the grid side of the A. C. input so that the filament would be at ground potential when the 60 cycle supply was used. The filaments were not grounded because a ground could not be found which was not interconnected with the ground on the lighting and power systems of the campus; even with the use of a six foot lead pipe driven in the earth around which was poured water a 60 cycle hum between it and filaments was loudly heard with nothing but the filaments connected. It was thought that the filament system would constitute sufficient ground, if the grounded side of the 60 cycle supply, when used in conjunction with the vacuum tube voltmeter, were connected to filament. Thus the C batteries 5 and 6 were put between the grid and alternating voltage input in the case of the grid circuit of the V. T. Voltmeter.

No observable increase in the V. T. Voltmeter plate current occurred when the 60 cycle main ground was connected to the grid of the amplifier tube, the slider of P_2 being connected to ground also. This was taken as an indication that the C battery, 10, might be placed , as placed normally, between the filament and the voltage input to an amplifier tube. This was done, but for the 60 cycle readings, it is seen in retrospect that it would have been better to have put the C battery on the grid side of the A. C. input when the voltage amplification was measured at 60 cycles. However, the points obtained at 60 cycles lie on what might be considered an extrapolation of the curve obtained by the accurate points obtained at higher frequencies by means of the oscillator. Any disturbing effects in the voltage amplification obtained at 60 cycles, irrespective of those obtained at higher frequencies, would be due to the possibilities that the equivalent of two grounds, capacitively coupled, existed, and that harmonics existed in the voltage source which might be amplified disproportionately, giving a slight over increase in the V. T. Voltmeter reading. Neither of these possibilities was substantiated in the results generally, however, since no disproportionate increase in V. T. Voltmeter reading was indicated by the curves at this or higher frequencies.

The transformer, T, indicates the connections of the transformer under test.

The condenser, 12, of 4 microfarads capacity, shown shunted across the amplifier plate voltage source, was for the purpose of providing a low impedance path for the plate current variations, especially at high frequencies. Its use was not essential since the impedance of a good B battery is quite low, and since in this case it was not used as a source for any other purpose except to supply the plate current of the one amplifier tube; it would tend to minimize battery impedance coupling between stages if the battery were used as a common source of plate current for the tubes of more than one stage.

The A, or filament battery, was common with the V. T. Voltmeter A battery supply. The voltage used on the amplifier tube filament proper depended on the amplifier tube used and the test made. Its voltage was kept constant by a high resistance voltmeter which was also used to keep the V. T. Voltmeter filaments at their rated voltage (5 volts) so that the calibration of the V. T. Voltmeter, which was made at this voltage, would remain constant as far as the filament voltage was concerned.

The B, or plate, batteries used on the amplifier tube consisted at most of 6 - 22.5 volt blocks of heavy duty B batteries, the number of blocks used depending on the test made. Where the voltage, as measured by an accurate high resistance voltmeter, read greater or less than one volt from that specified by the test to be run, dry cells were added, aiding or opposing, to correct the reading.

The C battery, 10, consisted of C battery blocks so tapped that the desired voltage might be obtained.

All grid leads were made as short as possible, with the switching arrangements necessary, and separated widely to minimize their capacity. All connections were soldered where possible; switch and potientiometer contacts were kept clean and tight.

The nature of the tests which were made in whole or in part on the transformers available are briefly summarized on pages 73-74 below. The more general idea underlying the tests and the purpose of individual tests will now be described.

It was naturally desired that the transformers be tested under representative conditions, that is, in conjunction with the apparatus and under the circumstances encountered in use, such as representative tubes, normal connections, and current and potential conditions. For this reason the receiving tubes of the types CX301A and CX299 were chosen as the representative tubes, a CX301A being used in most tests; the transformer connections were followed where marked under the assumption that it was properly poled; normal filament voltage, a plate battery of 90 volts, a C battery voltage of -4.5 volts and a low input voltage were, it was thought, the essential current and potential conditions under which all transformers should be tested. Other tests to be made were secondary and to verify the effect of different conditions in special cases. All of these tests were not made in any one case, but 15 of them were made on one transformer to show the effects on that transformer. The effect of these, of course, could only be shown one at a time everything else being held as normal.

The static characteristic curves of the amplifier tubes intended to be used in these tests are shown on pages 106-13 . It is seen that they were representative. All were new tubes except the UV201A which had seen about 100 hours of service. All the CX301A tubes, it will be noticed, had similar characteristics. The CX299 tube characteristics were dissimilar.

Test No. 1. It is almost universal practice now to use tubes of the CX301A or the CX299 type, and the tendency is toward the use of the larger CX301A (UV201A) tubes as amplifiers; the values $E_B = 90$ and $E_C = -4.5$ represent about the mean plate and grid fixed potentials recommended by manufacturers for amplifier tubes associated with their transformers; the values $E_B = 90$ and $E_C = -4.5$ should not saturate the iron of the amjority of transformers recommended for use with even higher plate battery potentials; manufacturers should properly pole their transformers; and the input voltage should be kept low and not so large that the tube operates off the straight part of its $e_g I_p$ dynamic characteristic. Therefore I believe that Test No. 1 is suitable for comparison purposes, and it was run on the 59 transformers available.

Tests Nos. 1a and 1b; Tests Nos. 6 and 6a. These tests were to show any differences due to the use of different tubes of the same type.

Tests Nos. 1 to 5. These were intended to verify for a given transformer and tube the effect of varying the values of the fixed grid and plate battery potentials. Evidently the flux density in the transformer and the operating point on the tube dynamic characteristic will both be changed by changes in potentials. Also the plate resistance and the amplification constant may both be changed, the latter very little, however, thruout the range employed. The values were not reduced to the extent, however, that current would flow in the grid circuit of the amplifier tube; thus $E_B = 45$ and $E_C = 0$ was not used. These values would theoretically give distortion.

Tests Nos. 6 and 6a. These tests were for the purpose of using CX299 type tubes under the other conditions of Test 1 for comparison purposes as before.

Tests Nos. 6, 7, 8. This series on the CX299 type were for the same purpose as Tests 1 to 5 on the CX301A type.

Tests Nos. 9, 10, 12, 13, 14, 15. These were special tests to show the effect, if any, of the not unusual conditions listed, under those Test Numbers, pages 73-74. These will be discussed under the results obtained.

Test No. 11. This test was for the purpose of showing the effect of increased input voltage on the amplification curve. It would be expected that the effective resistance of the transformer would be increased slightly. The consequently larger flux density variations would cause an increase in losses because hysteresis loss varies as $B^{1.6}$ and eddy current loss as B^2, if B is the flux density.

The method of making these tests was as follows. The V. T. Voltmeter conditions were made normal by setting its tube filaments at the proper voltage by means of the rheostat 4 of Fig. 11, closing the short circuit switch across the microammeter in the plate circuit, then connecting its plate battery, 1, and the resistance, 2, across it. The transformer to be tested was connected as shown at T while the V. T. Voltmeter was warming up. With the midpoints of switch S_1S_1' thrown down, switch S_2 thrown to the right, the 60 cycle supply was connected by means of a one way plug which always connected the grounded side of the supply to the filaments, to the potientiometer or voltage divider P_1. The switch 9 was kept closed at all times unless readings were being taken, since the slider of P_2 was not connected unless placed in contact by means of an improvised handle on the large switch points on top of the resistance box used as a potientiometer or voltage divider.

If the V. T. Voltmeter had been previously calibrated, a few points were checked to be sure that it was in calibration, and if it were not, it was calibrated in the usual following manner: first, only C battery 5, consisting of 23.5 volts, was used as grid bias, the plug being removed from jack 7. The microammeter switch was opened and the plate current read in microamperes and recorded in milliamperes on the especially designed printed data sheet in the third column under the main heading V. T. Voltmeter Calibration, opposite 0.0 volts in the first column. It was marked a since all currents obtained under a, with C battery, 5, alone, were plotted on the proper Calibration Curve Sheet and marked a. When C batteries 5 and 6 were both used in series, by inserting quickly the plug in jack 7 to lessen the time of short circuit of battery 6, the values so obtained were marked b, and so designated on the Calibration Curve Sheets when plotted. The voltage across 2 was adjusted, by a calibrated dynamometer type of voltmeter, to 100 volts. The slider of P_2 was connected so that .5, .6, 2, 3, 4, etc., volts up to 15 volts were impressed on the V. T. Voltmeter giving corresponding plate current readings which were due to the voltages impressed. It will be noticed that the full range of the microammeter was quickly reached, at which time it was short circuited and the milliammeter used. This milliammeter was a millivoltmeter with its shunt removed and was marked 0 to 100, altho its full deflection current was 25 milliamperes. This accounts for the constant .25 which was used on the data sheets above columns 2 and 7. Divisions might have been used but it would have been necessary to convert microamperes into divisions which would have been more inconvenient; in addition it was desired to bear directly in mind the value of the current which was flowing in the V. T. Voltmeter plate circuit. To 15 volts was about as high as the effective input voltage could be carried, since the maximum value of the input voltage was then 15 x 1.4 = 21.2 volts and the C battery voltage was about -23.5 volts. At this point the plug of jack 7 was inserted, bringing the C battery potential to -44 volts, and the input voltage was then increased up to 30 volts. Fig. 10b, page 24, shows the plate current variation and average value when the C battery E_{c2} is so large that plate current only occurs during the positive half of the grid input voltage cycle, the normal value of the plate current being zero with no grid input voltage.

In the case of each reading taken with the slider of P_2 connected across the desired voltage, the jack switch 9 was opened so that no current from the input supply would flow thru the resistance 8 and so reduce the input and introduce unnecessary calculations. The effect of this resistance was neglibible, however, except at input voltages of higher than about 5 volts.

In accordance with the desire to keep the voltage input to the amplifier tube low, it was found that an input voltage of .5 volt was the lowest voltage input reading that could be read within $\pm$ 3 per cent of the plate current increase, that is, .5 volt gave an increase of 9.5 microamperes and the meter could be read to about .25 of a microampere. The effect that this error would have on the voltage may be shown from the fact that an input voltage of .6 volts gave an increase of about 13 microamperes, an additional increase of 3.5 microamperes for .1 volt increase in voltage. It is seen that even a .5 microampere overreading in allowed V. T. Voltmeter plate current increase, when the oscillator was to be used as the source of voltage, would mean a voltage, taking this as an indication, was too large in the neighborhood of .5 volt by only .14 x .1 = .014 volts. The voltage would then be only $\frac{.014}{.5}$ x 100 or about 2 per cent too high. Thus the accuracy should be well within $\pm$ 3 per cent even with an under reading. This error was thought allowable since a mean curve would be closely obtained.

Readings for each frequency chosen were obtained by adjusting the filament, plate, and grid voltages to the values specified under the test to be made and impressing such a voltage, by means of the slider of P_2, that the V. T. Voltmeter plate current increased 9.5 microamperes; this voltage, assumed to be .5 volt, was then used as the input to the amplifier and the V. T. Voltmeter used to measure the voltage output of the amplifier. Thus immediately after the V. T. Voltmeter had been calibrated, or its calibration checked, the amplifier stage was properly adjusted, the switch S_2 left thrown to the right, switch S_1S_1' thrown up, the switch 8 opened and the milliammeter reading of the V. T. Voltmeter recorded in the column 7 on the Data Sheets. The switch 8 was then closed, switch S_1S_1' thrown quickly down to shorten the break in the voltmeter grid circuit, S_2 thrown to the left and the oscillator tubes and batteries connected so that the oscillator was adjusted for normal operation. The oscillator dials were turned to the proper settings by reference to an abridged chart prepared for the purpose from the main chart prepared by the manufacturers of the oscillator, the input to the V. T. Voltmeter adjusted to the equivalent of .5 volt - microammeter reading increase of 9.5 microamperes - and this input impressed on the amplifier at each frequency, and the reading of the V. T. Voltmeter taken and recorded as for the 60 cycle reading. Readings were taken at 23 frequencies so chosen that the points obtained at these frequencies would be uniformly distributed when plotted on the three section semi-logarithm paper used for plotting the voltage amplification curves.

All milliammeter readings were multiplied by .25 and microammeter readings changed directly to milliamperes before they were recorded under column 8 of the Data Sheets. The corresponding voltages were looked up on the proper curve on the Calibration Curve Sheet. It is again to be noted that when the amplified input voltage approached the value which would make the grid take current - the microammeter was taken out after calibration - the extra C battery, 6, was put in and the corresponding milliammeter reading, where the change was made, marked b. The corresponding voltages under b were then looked up on curve b on the proper Calibration Curve Sheet, just as those under a were looked up on curve a on the proper Calibration Curve Sheet.

When the amplifier output voltage at a given frequency corresponding to the V. T. Voltmeter plate current reading was looked up and recorded under the column headed E_2 on the Data Sheet, it was then divided by the amplifier input voltage E_1, recorded under the column headed E_1 on the Data Sheets, and the value so obtained recorded under the heading marked Voltage Amplification on the Data Sheets, opposite the frequency at which it was obtained.

(c) The Results Actually Obtained

Data for the voltage amplification curves of 59 different audio frequency transformers were obtained during the tests which extended over a period of about six weeks. A list of the transformers tested is given on pages 69, 70, 71, and 72; the results of the tests are shown graphically on Transformer Curve Sheets Nos. 1 to 30, pages 75 to 105.

The transformers were obtained, largely, on consignment for test purposes thru local wholesalers and retailers, hence the transformers were tested in about the order that they were available. About 27 manufacturers were represented, altho in some cases the information was meager and little was known about the transformer except its name. This was especially true of the lower priced transformers, as might be expected. All transformers were given Test No. 1 for general comparison purposes; the effects which Tests other than No. 1 were desired to show were largely for verification purposes, since they could theoretically be predicted or have been investigated many times, hence only a few of the other 17 tests were made more than once, as may be seen by the fact that of the 81 test runs made, 61 were under the conditions of Test No. 1. Of the 61 No. 1 Tests, 55 were on transformers of different type, 2 on one transformer as a recheck, and 4 on additional transformers of types previously tested to ascertain in a measure the uniformity of their construction.

Each manufacturer, or trade name where the manufacturer was not known, has been assigned a transformer curve sheet or sheets, and all curves of this manufacturer or trade name were plotted on this sheet or sheets. A summary of these assignments is given on pages 67-68, immediately preceding the Transformer Curve Sheets. In only two instances was more than one sheet used for a manufacturer or trade name. In one case, where practically all of the Tests were made on one transformer, namely No. 29, it was undesirable and impractical to show all of the curves on one sheet; thus Transformer Curve Sheets Nos. 20 to 23 inclusive, were used for this transformer. In the other case the data obtained by Test No. 1 on Transformer No. 4, was replotted to arithmetic scale for purposes of illustration (see Transformer Curve Sheet No. 31, page 105). The curves obtained will now be discussed generally and then in detail where thought necessary.

Three-section semi-logarithm paper was used for plotting the voltage amplification frequency curves. Semi-logarithm paper was used because it was desired to compare directly at the given frequencies the voltage amplification for a given equal voltage input; it has been shown desirable that the voltage amplification be the same for each frequency - the difference of relative energies at the different frequencies to determine the actual relative voltages impressed on the amplifier tube at these different frequencies. Thus the voltage amplification is plotted to arithmetic scale. A logarithmic scale is desired in plotting frequencies because the succesive notes within an octave bear a definite fixed frequency relation to each other, the octaves are given equal prominence on musical instruments, and therefore the octaves should be given equal prominence on the curves. This a logarithmic scale does and an arithmetic scale does not, as may be seen by referring to Transformer Curve Sheets Nos. 7 and 31, where in the former, page 81, the octaves, with reference to middle C, are equally distributed and in the latter, page 105, are crowded at the lower frequencies. Three sections of the semi-logarithm paper were necessary to cover the range of frequencies.

As a whole, only a few good transformers were in evidence and these, hardly without exception , may be described as having low ratios and comparatively large iron cores, altho these attributes did not always give a desirable characteristic.

Each individual curve will not be discussed , since many of the curves had similar characteristics. Variations in voltage amplification with frequency occurred generally on account of factors which have been mentioned. If a curve has a pronounced peak, such as curve No. 4, Transformer Curve Sheet (T.C.S.) No. 7, page 81, it means that the distributed capacity of the transformer was such as to make the secondary resonant. The sharpness of resonance would be determined by the impedance which the transformer had as a whole in the plate circuit of the vacuum tube used - this determining the voltage across the primary due to the input voltage - the equivalent resistance of the secondary at resonance, and the step up ratio of the transformer. Thus when series resonance occurred, and it only would give a pronounced localized peak in the voltage amplification curve, the impedance referred to the primary might be large or small at the resonant frequency; if large and the secondary equivalent resistance small, the peak might be comparatively large. If it were small, the peak might be comparatively small. However if secondary resonance occurred at a low frequency, but after the primary impedance had become practically constant, it would be characterized by a peak which extended over quite an octave range since the actual frequency range was drawn out farther than at the higher frequencies. T.C.S. No.31, page 105, shows how the sharply peaked curve No. 4 of T.C.S. No. 7, page 81, obtained at a comparatively high frequency is extended when drawn to an arithmetic frequency scale. The Curve No. 4 T.C.S. No. 7, page 81, falls rapidly after resonance indicating that the effect of the transformer distributed capacity after the frequency of resonance had been passed was sufficiently high to make the equivalent primary impedance low enough that the voltage developed across it was small; hence the secondary voltage dropped rapidly for two reasons. Curve No. 3, T.C.S. No. 21, page 95, is an example where after resonance occurred the primary equivalent impedance was not reduced greatly until about 1000 cycles later. Resonance occurred, however, at about the same frequency as it did in the case of the transformer for which Curve No. 4 T.C.S. No. 7, page 81, was plotted. This indicates greater secondary inductance in the former. It should be noted that in many cases the portion of the curve plotted after the effect of resonance had disappeared from a resonant curve fits in with what might have been expected to be a prolongation of the portion of the curve plotted just before the first effects of resonance were approached e.g. the curves on T.C.S. No. 21 page 95.

Very few transformers have sufficient impedance at the lowest frequencies to obtain the amplification they have at higher frequencies. The use of a low secondary to primary turn ratio enables the low ratio transformer to have a higher primary inductance for a given effective distributed capacity. Thus the good curves which were obtained were for transformers having a ratio of 1 to 3 or lower; having merely a low ratio of course did not mean a good curve, because the transformer might not have had sufficient primary inductance, or was resonant at an undesirable frequency. Some curves rose rapidly due to insufficient primary inductance, were flat for a while after the impedance was sufficiently high to be about two times the plate resistance, showed resonance then, perhaps, during which time the curves peaked, and fell rapidly after resonance because by this time of the effects of distributed capacity. Such a curve is

No. 1 T.C.S. No. 1, page 75.

Some of the curves rose rapidly due to insufficient primary inductance, and started falling again due to the effective distributed capacity almost immediately, not being apparently resonant at any frequency. Such curves for examples are Nos. 3 and 4, T.C.S. No. 2, page 76.

Some curves rose rapidly, started to fall due to distributed capacity, rose again due to resonance, and fell sharply after resonance. Such a curve is No. 2, T.C.S. No. 3, page 77.

In some cases the curves rose continuously with frequency indicating a very low effective plate load impedance, comparatively, at all frequencies in the desired range. The only examples of this occurrence are shown as Curves 2 and 3, T.C.S. No.17, page 91 . Apparently resonance was being approached in the neighborhood of 10000 cycles.

Several types of transformers made by a manufacturer were tested in many cases, including old and new designs, and considerable improvement in design is shown generally in such cases. Thus compare Curves 1 and 3, T.C.S. No.5, page 79 Curve 1 is for an old type of transformer used originally primarily for broadcast reception, but now used almost wholly for code work, since it amplifies frequencies in the neighborhood of 1000 cycles extraordinarily well and amplifies very little, comparatively, at higher or lower frequencies. Curve No.3 is for a transformer now used for broadcast reception, and is a decidedly better curve altho not nearly so good as several obtained.

Curve No.2, T.C.S. No.11, page 85 , Curve No. 2, T.C.S., No.13, page 87 , Curves 1 and 2, T.C.S. No.20, page 94, Curves Nos. 1 and 2, T.C.S. No.26, page 100 , Curve No.2 T.C.S. No. 27, page 101 , and Curve No. 2 T.C.S. No.28, page 102, are the best obtained under the conditions of Test No.1.

Concerning the special Tests, Curves 1,2,3,4,5,6,7, and 8, T.C.S. No.21, page 95, show respectively the results of Tests Nos. 1,2,3,4,5,6,7, and 8, with Transformer No.29. Curves 1,2,3,4, and 5, are for different values of E_B and E_C as follows: 1, $E_B = 90$, $E_C = -4.5$; 2, $E_B = 90$, $E_C = -3$; 3, $E_B = 67.5$, $E_C = -3$; 4, $E_B = 67.5$, $E_C = -1.5$; 5, $E_B = 135$, $E_C = -9$.

It would be expected that the tube resistance for these conditions would be in the decreasing order of magnitude 3,4,1,5,2. Substituting in the approximate formula $R_p = \frac{\mu}{K(\frac{E_B}{\mu} + E_C)}$, where K is a constant and μ is the amplification constant, which for this tube was about 7.25 at low plate and grid voltages, and about 7.4 for $E_B = 135$ and $E_C = -9$, as may be approximately determined from its E_C Ip Static Characteristic Curves, page 109, by dividing at the points of operation a suitable grid voltage change giving a certain plate current change into the plate voltage change that brings the plate current back to its original value.

on another curve, we get for the curves 1,2,3,4,5 respectively, the values $R_p = \frac{.91}{K}, \frac{.77}{K}, \frac{1.15}{K}, \frac{.93}{K}, \frac{.8}{K}$. These values actually give the decreasing order of magnitude 3,4,1,5,2 as expected above.

It is seen that the lower plate resistance values give the higher peak values, and that in the case of Curve No.2 where the plate resistance is considerably lower the amplification is noticeably greater. The peaks become less pronounced as the plate resistance increases because of the decreased relative ratio of equivalent plate load impedance and the plate resistance itself; the distributed capacity has, in the neighborhood of the frequency of resonance, so decreased the equivalent plate load impedance that the ratios are now critical. The point of resonance is apparently the same however.

Curves Nos. 6,7, and 8 on this Transformer Curve Sheet behave in the same manner. The amplification constant of this CX299 tube (Vacuum Tube No.1) was about 6.5 for the conditions of Curve 6, and 6.8 for Curves 7 and 8. (See $E_C I_p$ Static Characteristic Curve Tube No.1 page 106). The relative plate resistances for the conditions of Curves Nos. 6,7, and 8 were respectively $\frac{.69}{K'}, \frac{.81}{K'}, \frac{.98}{K'}$. Thus the transformer gives less amplification due to a lower tube amplification constant, and curve shapes which show for these dry cell tubes of relatively higher resistance, compared with the CX301A type, that the amplification rises more steeply due to lower load impedance plate resistance ratio at low frequencies. Evidently also the load impedance has been decreased to such an extent, compared with the higher resistance of the tube, that resonance serves to make the curve flat where otherwise it would have fallen off rapidly.

Curve No.1, T.C.S. No.20, shows the average curve plotted from the data of three No.1 Tests on Transformer No.29 at relatively large time intervals. The points so overlapped that all three sets of data could not be separately plotted on the same sheet conveniently. These three reruns were made to check the accuracy of the determination and since the voltage amplification gave a maximum variation of ± 5 per cent considering the largest variation of points at any frequency, it is believed that the mean of the points gave an accuracy for the curves obtained well within ± 3 per cent, unless a constant error was present thruout all runs. Curve No.2 on this Sheet shows the curve of another transformer - Transformer No. 30 - of the same type. Evidently its ratio was not quite so great since it gave slightly lower amplification and a somewhat flatter curve. It peaked at about the same frequency however as Transformer No.29 indicating that its distributed capacity was higher.

Curves Nos. 1,9,11,12,10,13, and 14 T.C.S. No.22 page 96 show the effect of the conditions of Tests Nos.1, 9,11,12,10,13, and 14 on Transformer No. 29. Curve No. 1, showing the average result of Test No.1, was included for comparison purposes as it was on T.C.S. Nos. 20,21,22,and 23. Test No. 9 shows the effect of grounding the frame and core of the transformer. The higher relative amplification indicates less secondary leakage reactance due to a change in the difference in the composite pattern of the electrostatic fields. The total effective distributed capacity is not changed much, since the peak occurs at about the same place and the same relative curve shape is obtained in this case. None of the transformers tested had provisions for ground connections, and since it is not general, this was not one of the conditions of Test No. 1.

Curve No.11 for Test No.11, which was for the conditions of Test No.1 except that the input voltage was increased to 1 volt, shows that the effects of hysteresis and eddy current losses, which were assumed negligible in obtaining a simplified transformer reactance load diagram, exist in sufficient magnitude to decrease the peak value considerably, the part of the curve up to the effect of resonance only slightly, and the part of the curve after the effect of resonance has been passed to quite a large extent.

Curve No.12 for Test No.12 shows that the effect of the resistance and capacity of long plate leads is practically negligible for a one stage amplifier where there is no common battery or lead coupling effects.

Curve No.10 for Test No.10 shows that the effect of connecting the secondary terminals opposite to their markings was to change the distribution of the interleaved distributed capacity such as to leave the equivalent load impedance somewhat greater, and hence the voltage amplification was greater after the high frequencies were approached.

Curves Nos.13 and 14 for Test Nos. 13 and 14 were to simulate the conditions when the filament voltage was not adjusted properly. The effect of increasing the filament voltage above normal would be to decrease the tube resistance, and decreasing the filament voltage would be to increase the tube resistance. Thus for Curve No.13, which is for an under voltage, the curve is flatter, and the general shape is similar to the reference curve No.1 but is lower practically all the way; Curve No. 14, which is for a higher filament voltage and hence lower tube resistance, is higher than reference Curve No.1, as would be expected.

Curves Nos. 1,2,3,4, T.C.S. No.23, page 97, show the results of Tests Nos.1b, 6, and 6a, respectively, on Transformer No.29. The conditions for Curves Nos. 2,3, and 4 were the same as for Curve No. 1, Test No. 1, except that different tubes - No.5 (UX201A), No.1 (CX299), and No. 2 (CX299) - with normal filament voltages were used.

The CX299 tubes have a higher resistance and lower amplification constant than the 01A type tubes, hence their curves, represented by Curves 3 and 4, have greater slopes than the Curves 1 and 2 for the O1A type tubes at the lower frequencies and do not peak at the higher frequencies as explained above. Curve No.4 shows that Vacuum Tube No.2 had a higher tube resistance than Vacuum Tube No.1. Curves Nos. 1 and 2 are practically identical since the tubes are.

Curves Nos.2 and 3 T.C.S. No. 27, page 101, show the results of using Vacuum Tubes No.3 (CX301A) and 4 (CX301A) on Transformer No.58. Tube No.3 is evidently and was a higher resistance tube.

Curves Nos.3 and 4 T.C.S. No.28, page 102 show in exaggerated form what may occur if the transformer secondary leads are made long and wrapped together. The secondary connections were made of telephone cable about 5 feet long. The additional distributed capacity effects are pronounced as may be shown by comparing these Curves 3 and 4 with Curves 2 and 4 respectively, where in the latter curves the grid leads were short.

It is believed that any curve shown on the Transformer Curve Sheets can now be interpreted on the basis of the discussion given above. All special tests have been considered, but all No.1 Tests have not since principles have been discussed. An indication of what voltage amplification a transformer will give at 30 cycles may be obtained by extrapolating the curves.

The Calibration Curves of the V. T. Voltmeter pages 195-8, will now be briefly discussed. The Curves a and b on Calibration Curve Sheet (C.C.S.) No. 1, page 195, were taken first and represent the first calibration; the Curves on C.C.S. No. 2, page 196, were taken as a re-check. It was necessary to remove the apparatus to make way for other laboratory work in one instance and the Curves on C.C.S. No. 3, page 197, were obtained on the third calibration after the apparatus was set up again. Calibration Curve Sheet No.4, page 198, was made necessary because the auxiliary C battery 6, Fig. 11, page 28, was accidentally short circuited between runs and it was necessary to replace it. It will be noticed that Curve a on C.C.S. No. 4, page 198, is identical with Curve a on C.C.S. No. 3, page 197. Thus the rerun calibration with this C battery, 6, Fig. 11, page 28, was checked and a new curve b, plotted on C.C.S. No.4, was obtained which differed from the corresponding curve on C.C.S. No. 3 because the new auxiliary C batteries put in as a replacement had a slightly higher voltage. After this calibration the battery potentials and tube conditions remained constant, so that a recheck of a few points taken about every 5 tests showed no new calibration necessary. There was no current furnished by the C batteries, the filament voltage was adjustable, and the B batteries furnished only a small current except at the instant of measurement of comparatively large alternating voltages, so there was little to affect the calibration.

Let us now calculate roughly the inductance of the primary circuit of a transformer which gives practically a flat characteristic down to low frequencies where the distributed capacity is of little effect. The assumptions will be made, as on page 18 , that the resistance of the tube was 12000 for the conditions of Test No.1 and that the primary resistance was negligible compared with its resistance. Curve No.1 T.C.S. No.20, page 94, is one on which the voltage amplification does not increase but about 10 per cent from 100 cycles until it begins to show resonance effects, so it may be assumed to have a reactance of $2 R_p = 24000$ ohms at 100 cycles. Therefore, under these assumptions $X_{L_p} = 24000$ ohms

or $L_p = \frac{24000}{2\pi 100} = \frac{100}{\pi} = 38.2$ henries

The reactance at 30 cycles would be

$X_L = 2\pi 30 \times 38.2 = 7200$ ohms hence the amplification at this frequency, referring to Fig. 2 page 9 , would be about .6 of the amplification where the curve is flat or about $.6 \times 21.6 = 13$. This value is about the value obtained by extrapolation.

The amplification constant of the tube was about 7.25, therefore, the voltage across the primary was

$7.25 \times .5 \times .907 = 3.3$ volts approximately, at 100 cycles. The voltage amplification was about 20 at this frequency and since the input was .5 volt, the voltage across the secondary was 10 volts. The transformer ratio was therefore about $\frac{10}{3.3} = 3$, assuming negligible flux leakage.

The ratio was stated to be 2.2 on Transformer 3, the curve of which appears as Curve No.1 T.C.S. No. 3, page 77. Assuming that it has attained full voltage amplification exclusive of resonance effect at 500 cycles, we see that the amplification was about 18.5. If the tube amplification constant was 7.25, measured as described above, the voltage across the primary was 7.25 x .5 = 3.67 volts. The secondary voltages 18.5 x .5 = 9.25. The ratio, neglecting leakage and losses, was 9.25/3.67 = 2.52, indicating that the tube amplification constant was greater than 7.25, or that the turn ratio of secondary to primary was greater than 2.2. An amplification constant of 8 would give the value 2.3.

Some idea of the magnitude of the effective secondary distributed capacity may be obtained upon the assumption that at resonance in the case of this Curve No.1, T.C.S. No. 20, page 94, the primary impedance is still high enough to give the full voltage amplification due to the tube. Under this assumption the primary apparent inductance is not changed by the secondary circuit, since the secondary current acts only to increase the primary resistance when the secondary is resonant. Since the primary inductance was 38.2 henries and the ratio of secondary turns to primary turns was 3 to 1, the secondary inductance would then be $(3)^2\ 38.2 = 422$ henries. Since the frequency of resonance was at about 4500 cycles, the secondary equivalent reactance was then

$$X_L = 2\pi 4500 \times 422 = \frac{1}{2\pi f_r C} \quad \text{at resonance}$$

where C is the distributed capacity.

Then $$C = \frac{1}{(2\pi)^2\ (4500)^2\ 422} \text{ farads}$$

$$= 3.07 \text{ micro-micro-farads}$$

This value is evidently quite too low because of the assumption made. Its value will probably be several times this value. This calculated value would be of the order of the V. T. Voltmeter input capacity; thus the V. T. Voltmeter would affect, to quite an extent, the primary impedance and the frequency of resonance which would occur earlier because of it. However an amplifier tube would have a capacity of about this magnitude also. The distributed capacity of this transformer is probably quite low, however, compared with several others, since it contains a very large iron core.

It is now possible to draw some conclusions regarding the requirements of transformers to be used as coupling devices in audio frequency amplifiers in which it is desired to reproduce music and other sounds faithfully. It is evident that with so many conditions which may affect the shape of the transformer voltage amplification curves that it is necessary, in order to get good results, to design the transformer to fit specific conditions,and to use it ,or have it used,only under the conditions for which it was designed, or is found suitable.

Some manufacturers of transformers, especially some of those who sell transformers as separate items,claim superiority for their products on the basis of advertised curves. Oftentimes the conditions under which the transformers were tested are not given, and as has been seen these conditions are essential. The curves may not represent operating conditions, and oftentimes, in my opinion, do not represent the transformer under any conditions. A curve may be shown by an advertiser as rising thruout the desired range and plausible reasons given- to the layman- why the curve should rise. In another case a curve may be shown as having a falling characteristic, and perhaps more plausible reasons given why the transformer should have such a characteristic. Certain pieces of broadcasting and receiving apparatus are not perfect, and some manufacturers, apparently, do not try to work outside the limits of perfection of this apparatus. Some try to compensate for existing defects,but compensation,if it is effected, may only be a temporary remedy and it does not suggest the goal of flexibility and perfection in apparatus. Compensation remedies which have been suggested are the staggering of transformer characteristics in successive stages, shunting the transformer primaries or secondaries with resistances or condensers, or making the transformer characteristics rising or falling instead of flat. It is often necessary however to apply drastic compensation measures to some transformers themselves to make them useable. It is believed that many manufacturers were not cognizant of the characteristics of their transformer products, and that this was especially true of the apparently cheaply built , illy designed, but usually low priced transformers made to simulate the appearance of transformers of recognized quality. The tests on these types of transformers were of especial interest and confirmed in general the above expressed belief.

The following summary may be made regarding the factors which enter into the design of a transformer which is to give sensibly constant voltage amplification from 30 to 8000 cycles.

The ratio of the transformer primary impedance to the tube resistance must be two, or above, at the lowest frequency if at least 90 per cent of the amplified input voltage is desired across the primary. This then involves the tube resistance which must be known. If the transformer is to be used with several tubes, its primary should have an impedance of twice the value of the resistance of the tube of highest resistance. Since the tube resistance will vary under different potential conditions, then the primary should have twice the tube resistance under its condition of highest resistance.

The primary impedance may be made large by making the number of turns large, the core cross-section large, and by using an iron core of high permeability and low reluctance. With a certain number of primary turns, the secondary will have about r times as many to obtain a step-up voltage ratio of r. But the greater the number of secondary turns the larger the distributed capacity of the secondary, so it is desirable to use as much iron as feasible, iron of high permeability and low reluctance, and a low ratio so that the number of primary turns for a required minimum primary impedance or inductance may be kept at a minimum, so that in turn the distributed capacity of the secondary can be kept at a minimum. It has been shown that the effect of a distributed capacity C across the secondary is equivalent to (r^2) C in the primary; hence its effect may be greatly reduced by the employment of the above principles. These principles could be followed to the extent that the distributed capacity of a transformer would be so reduced that it would not decrease the primary impedance below $2R_p$ thruout the desired frequency range. Also this distributed capacity would then not be likely to cause resonance thruout the frequency range. As was indicated in the calculation on page 60, only very small capacity is needed, however, to cause resonance within the audio range when the secondary inductance has a value of 300 to 400 henries.

The characteristics are also affected by hysteresis and eddy current losses, the magnitude of the input voltage, poling, the position of the operating point on the magnetization curve of the transformer, and the manner in which the transformer is wound. The first is negligible in effect except in so far as it affects the height of a resonant peak. The characteristic obtained at a given frequency by measuring the amplification obtained for different values of input voltages is called the load characteristic of a transformer at that frequency. It will be a falling characteristic because both eddy current and hysteresis losses increase with the flux density, B, to a power greater than unity and since the flux increases will be about equal until saturation in the iron is approached, the losses will be increased more by the increases in the flux than they are decreased by the flux decreases. When saturation is approached, the flux changes will be reduced; this causes a further reduction in voltage amplification and gives rise to distortion. A load characteristic taken at a high frequency will fall off more in proportion than it will for a low frequency because of magnetic "skin effects". These losses also will have little effect, except at secondary resonance, if the input voltage is not sufficient to saturate the iron during the positive half of the cycle.

The effect of poling is to change the distributed capacity to some extent, so that a transformer should be poled to minimize its distributed capacity.

The effect of decreasing the number of primary turns is to decrease the effective number of primary ampere turns. The value of the plate current, when no alternating input voltage is impressed on the grid of the amplifier tube, is the current which sets up the initial magnetization. The resistance of a transformer is low compared to a tube's resistance, hence a decreased number of primary turns would increase the steady value of the plate current but little, if any, since the mean turn length would also be increased. The primary ampere turns would decrease, then, in about the ratio of the decrease in primary turns. This would not be an important factor except for high voltage inputs - which might reduce the flux to zero during part of the negative half of the cycle - since the transformers usually operate now, too high on the magnetization curve.

The primary and secondary windings are usually, of necessity, wound in layers one above the other. The fine wire that must be used practically prohibits the breaking up of the primary and secondary into several interlaced sections to prevent flux leakage. The secondary is often wound next to the core to minimize leakage however. The turns and layers are not usually put on in haphazard fashion but in a regular compact manner. The capacities between turns and layers will be determined to a large extent by the character and quantity of the insulation used.

It is clear from the results obtained, which are believed to be representative, altho by no means exhaustive either quantitatively or qualitatively, that transformers satisfactory under even favorable conditions are in the minority, leaving out of consideration transformers which are now obsolete. It is evident that great progress has been made, however, and some of the transformers tested might be said to be satisfactory - they are better at present than most loudspeakers. Enough progress has been made to show that the transformer, barring new discoveries, will be the practically exclusive interstage audio frequency coupling device of the future.

Identification of Transformer Curve Sheets According to Manufacturer or Trade Name

Transformer Curve Sheet No.	Manufacturer or	Trade Name
11	General Radio	
2	Rauland	
3	Bremer Tully	
4		Meloformer
5	Radio Corporation of America	
6	Acme	
7	Thordarson	
8	Premier	Hedgehog
9	Jefferson	
10	Crosley	
11	Sparton	
12	Erla	
13	American Transformer Company	
14	Federal	
15	Atwater Kent	
16		Supertone
17		Kelford
18		Crescent
19		Volutone
20,21,22,23	Silver Marshall	

Identification of Transformer Curve Sheets
According to Manufacturer or Trade Name

(Continued)

Transformer Curve Sheet No.	Manufacturer or	Trade Name
24		Songbird
25	Freed Eisemann	
26	Bosch	
27	Fada	
28	Stromberg Carlson	
29	Brandes	
30	Grebe	
31	Thordarson	

Transformer No.	Name and Description	Tests Made Nos.	Corresponding Transformer Curve Sheet No.
1	General Radio Type 285, Ratio 1:5	1	1
2	Rauland Lyric Type R 500 Serial No. 65607	1,10	2,2
3	Bremer Tully Type 210 Ratio 1:2.2	1	3
4	Meloformer(no markings)	1	4
5	Bremer Tully Type 410 Ratio 1:4.7	1	3
6	Acme Type A-2	1	6
7	Thordarson Type R150 Ratio 1:3.5	1	7
8	Hedgehog No. 103 Ratio 1:3, (Premier Elec.)	1	8
9	Jefferson Star (old type) Ratio 1:3	1	9
10	Crosley(no markings)	1	10
11	Sparton No. 3 (HS)	1	11
12	Sparton No. 2 (HS)	1	11
13	Thordarson (old type) Ratio 1:6	1	7
14	Federal No. 65	1	14
15	Erla, Ratio 1:3.5	1	12
16	Amertran(successor to AF6)	1	13
17	General Radio 231A	1	1
18	All-American Type R-12 Ratio 1:3	1	2
19	Atwater Kent (first stage-new type 1926)	1	15

Transformer No.	Name and Description	Tests Made Nos.	Corresponding Transformer Curve Sheet No.
20	Atwater Kent (second stage-new type 1926)	1	15
21	General Radio Type 367 (output)	1	1
22	Supertone (Grand's) Ratio 1:5	1	16
23	Kelford No. 62A (Grand's) Ratio 1:3.5	1	17
24	Kelford No. 64A (Grand's) Ratio 1:5	1	17
25	Kelford No. 74A (Grand's) Ratio 1:5	1	17
26	Crescent No. 260 Ratio 1:6, (sample No. 1)	1	18
27	Volutone, Ratio 1:3.5	1	19
28	Crescent No. 260 Ratio 1:6, (sample No. 2)	1	18
29	Silver-Marshall No. 220 (sample No. 1)	1 1b, 2, 3, 4, 5, 6, 6a, 7, 8, 9, 10, 11, 12, 13, 14	(20, 21, 22, 23) 23, 21, 21, 21, 21, 23, 23, 21, 21, 22, 22, 22, 22, 22, 22
30	Silver-Marshall No. 220 (sample No. 2)	1	20
31	General Radio Type 285 Ratio 1:2	1	1
32	Atwater Kent (sample No. 2) (first stage-new type 1926)	1	15
33	Erla 'Concert Grand' Ratio 1:3	1	12
34	R.C.A. UV712 Ratio 1:9	1	5

Transformer No.	Name and Description	Tests Made Nos.	Corresponding Transformer Curve Sheet No.
35	All-American Type R-21 Ratio 1:5	1	2
36	Jefferson Type 38	1	9
37	Jefferson Star(new) Ratio 1:1.5	1	9
38	Jefferson Star(new) Ratio 1:6	1	9
39	Jefferson Star(new) Ratio 1:3	1	9
40	Federal No. 226	1	14
41	Federal No. 65A	1	14
42	All-American Type R-15 Ratio 1:5	1	2
43	Brandes	1	29
44	R.C.A.(Catalog No.409415) Radiolas 3,3A	1	5
45	Freed Eisemann	1	25
46	Thordarson Type R200 (sample No. 1)	1,6	7,7
47	Thordarson Type R200 (sample No. 2)	1	7
48	Songbird Mastertone Ratio 1:3.5,(sample No. 1)	1	24
49	Songbird Mastertone Ratio 1:3.5,(sample No. 2)	1	24
50	Bosch(Cruiser first-stage)	1	26
51	Bosch(Cruiser second-stage)	1	26
52	Fada(old type)	1	27
53	Stromberg Carlson 4A	1,15	28,28

Trans-former No.	Name and Description	Tests Made Nos.	Corresponding Transformer Curve Sheet No.
54	Stromberg Carlson 4B	1,15	28,28
55	Amertran DeLuxe first stage	1	13
56	Amertran DeLuxe second stage	1	13
57	Radiola 28 second stage	1	5
58	Fada 1927 type first and second stage	1,1a	27,27
59	Grebe No. 251 second stage	1	30

Description of Tests

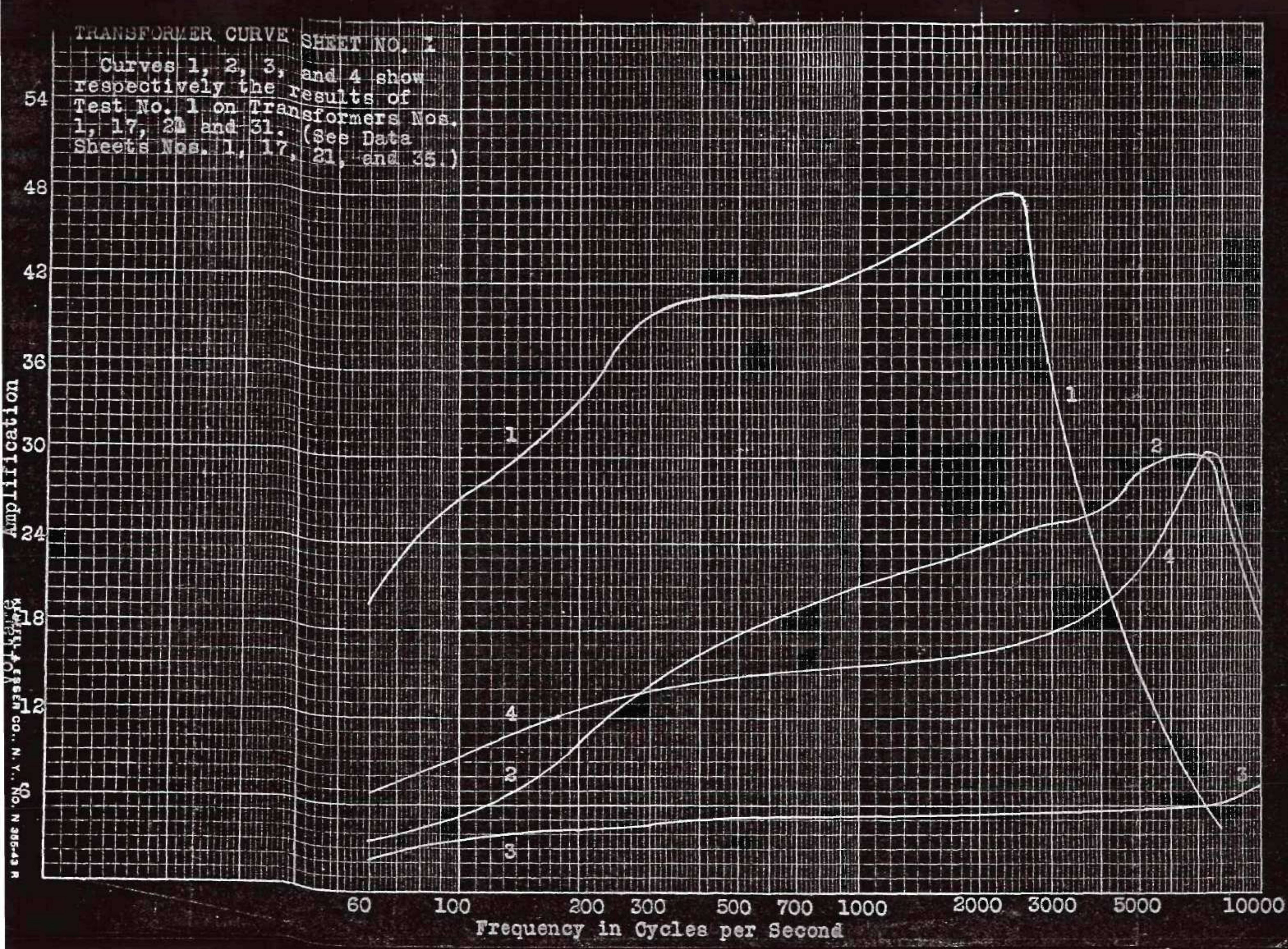
Test No. 1	Transformer used in conjunction with CX301A Vacuum Tube(No. 4); Plate Battery Voltage, E_B = 90 volts; 'C' Battery Voltage, E_C = -4.5 volts; Filament Voltage, E_F = 5 volts; Input voltage = 0.5 volts; transformer markings followed when shown.
Test No. 1a	Same as No. 1 except CX301A tube No. 3 was used.
Test No. 1b	Same as No. 1 except UX201A tube No. 5 was used.
Test No. 2	Same as No. 1 except E_C = -3 volts.
Test No. 3	Same as No. 1 except E_B = 67.5 volts, E_C = -3 volts.
Test No. 4	Same as No. 1 except E_B = 67.5 volts, E_C = -1.5 volts.
Test No. 5	Same as No. 1 except E_B = 135 volts, E_C = -9 volts.
Test No. 6	Same as No. 1 except tube was CX299 No. 1 with E_F = -3 volts.
Test No. 6a	Same as No. 1 except tube was CX299 No. 2 with E_F = -3 volts.
Test No. 7	Same as No. 1 except tube was CX299 No. 1 with E_B = 67.5 volts and E_C = -1.5 volts.
Test No. 8	Same as No. 1 except tube was CX299 No. 1 with E_B = 67.5 volts and E_C = -3 volts.
Test No. 9	Same as No. 1 except transformer frame was grounded to negative filament.
Test No. 10	Same as No. 1 except transformer secondary terminals were connected opposite to their markings.
Test No. 11	Same as No. 1 except input voltage was kept constant at 1 volt.
Test No. 12	Same as No. 1 except that the plate by-pass condensers across the B battery of the amplifier tube were removed and the plate of B-battery leads made 50 feet long.
Test No. 13	Same as No. 1 except that E_F = 4.5 volts.

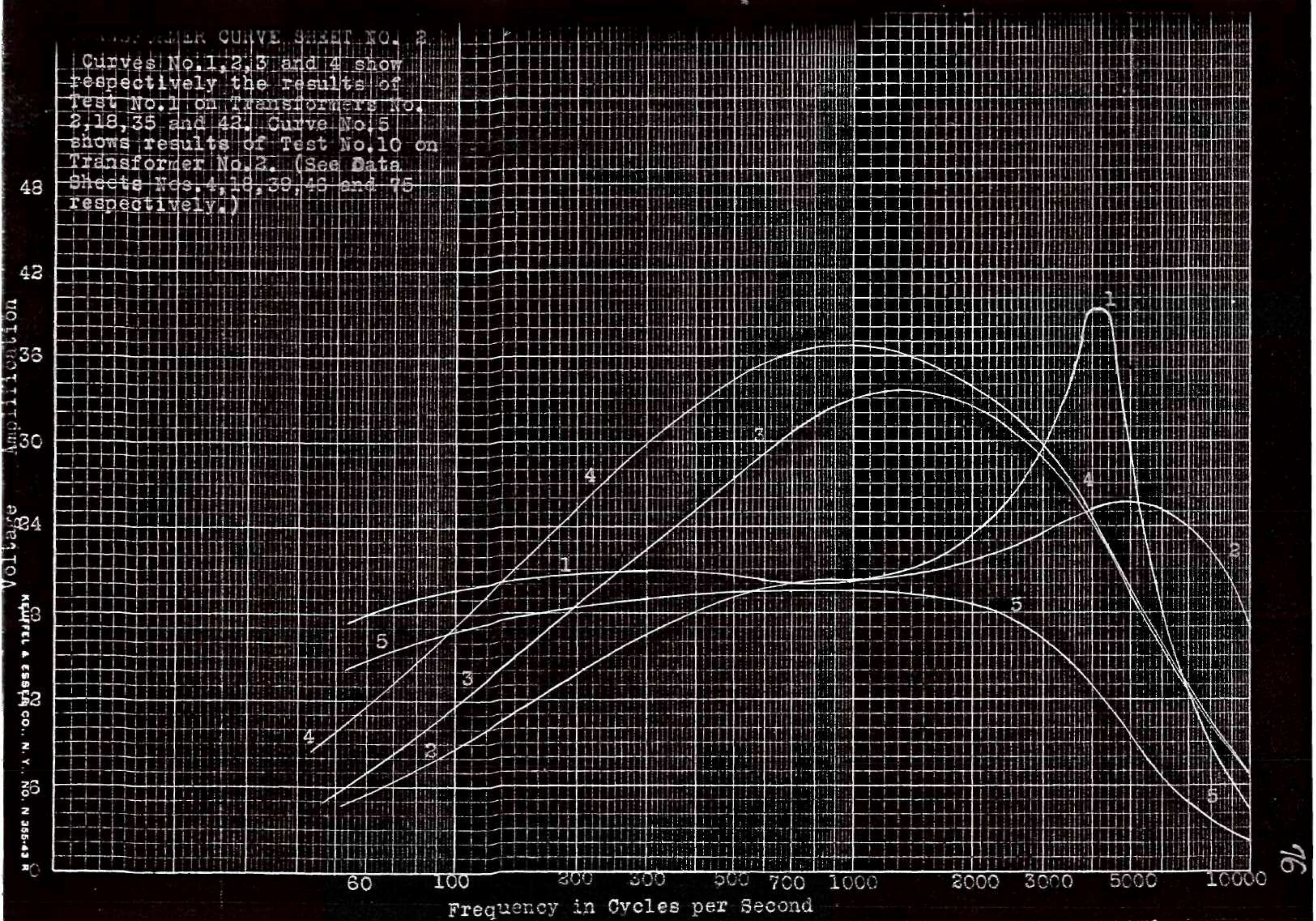
Description of Tests

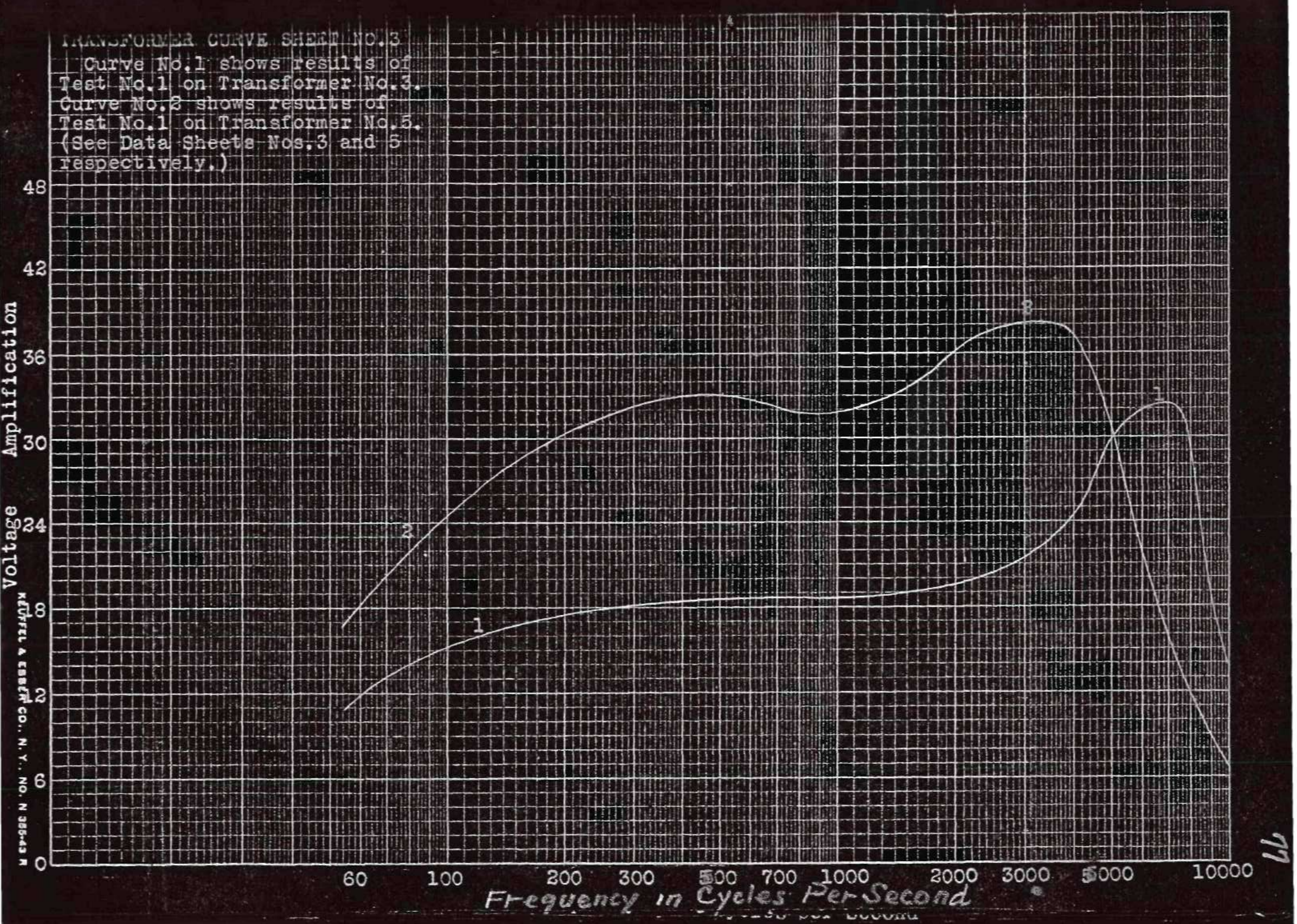
(Continued)

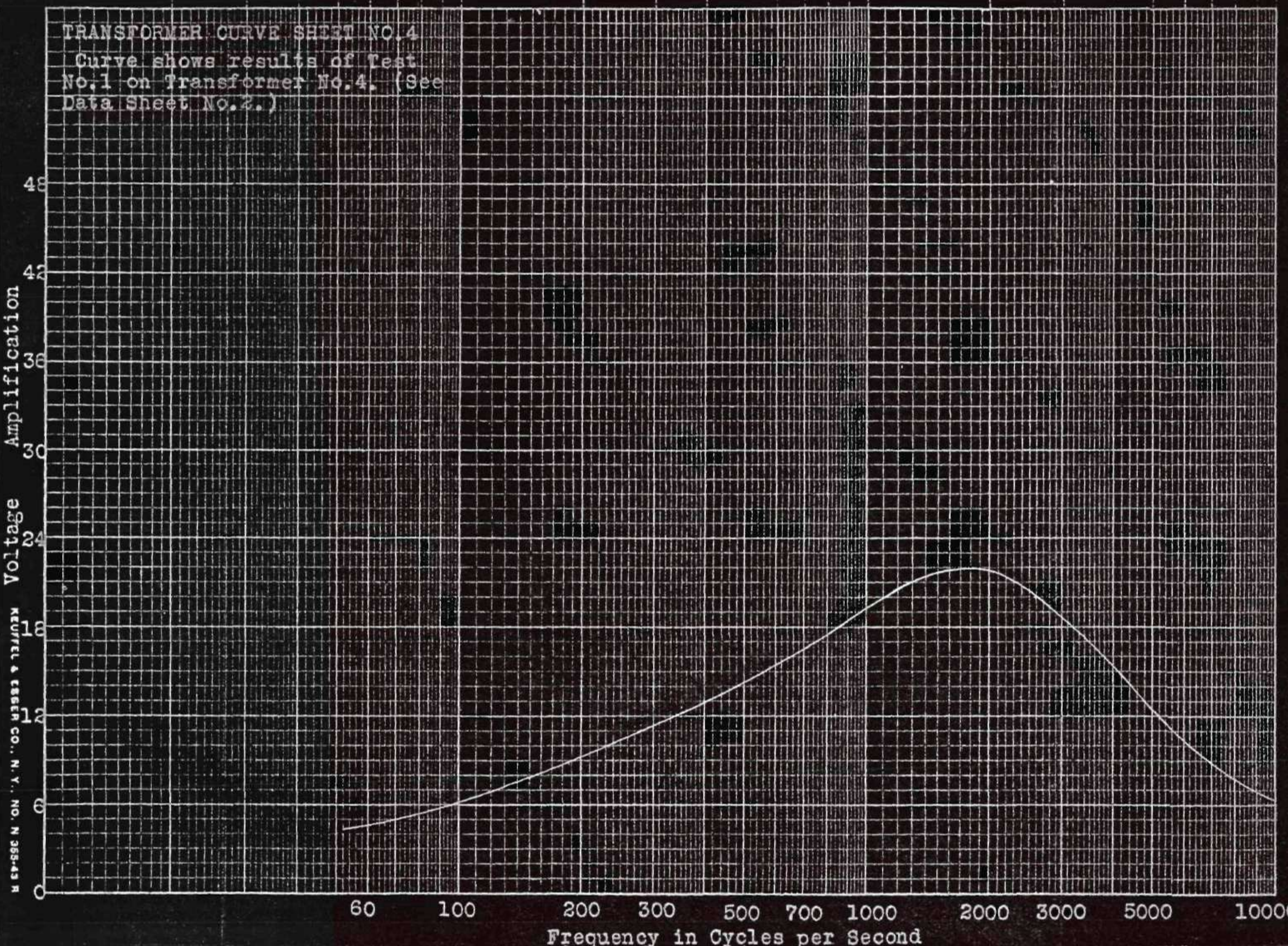
Test No. 14 Same as No. 1 except that E_F= 5.5 volts.

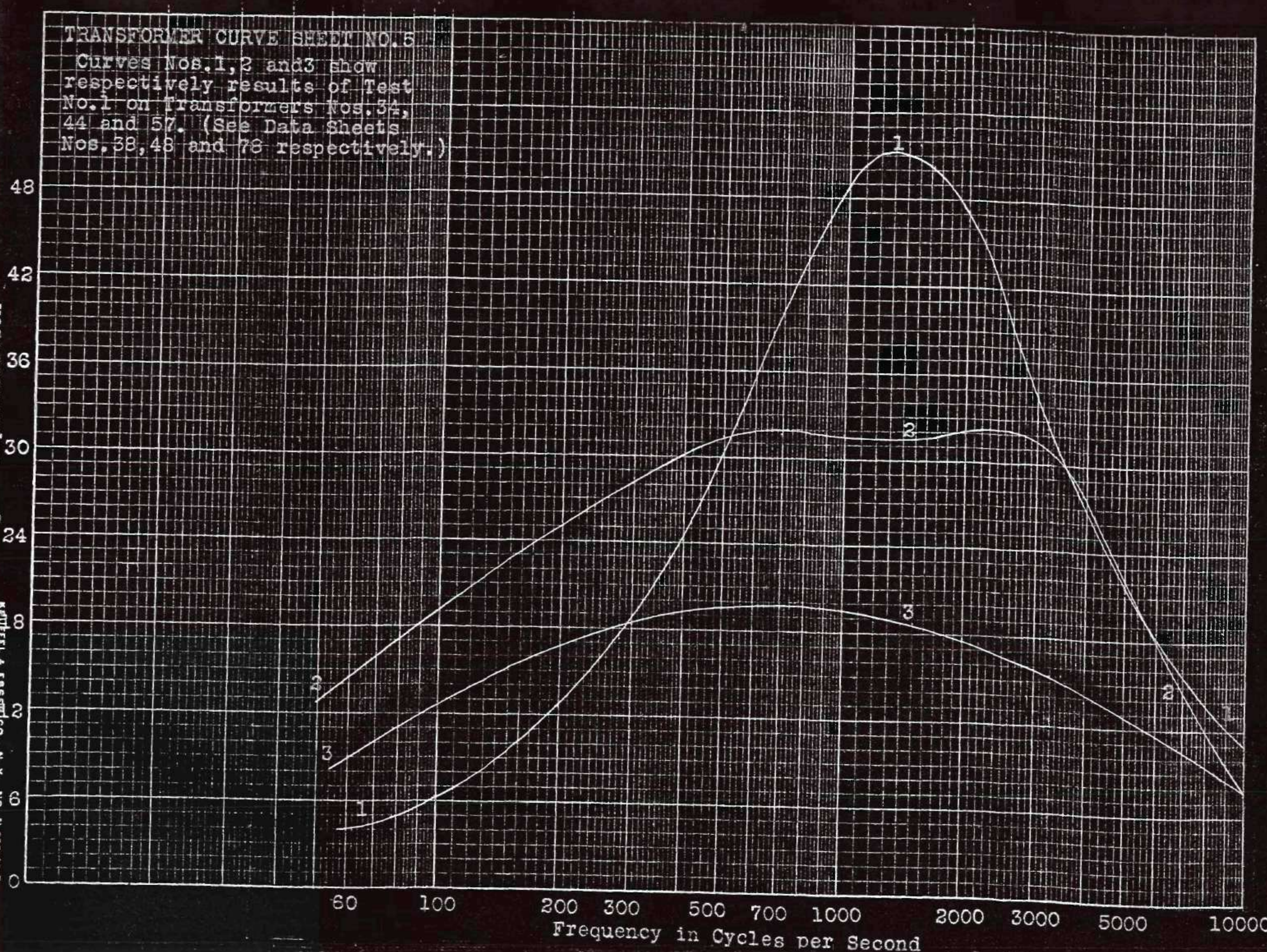
Test No. 15 Same as No. 1 except that the transformer secondary leads were made about 5 feet long.


TRANSFORMER CURVE SHEET NO. 1
Curves 1, 2, 3, and 4 show respectively the results of Test No. 1 on Transformers Nos. 1, 17, 21 and 31. (See Data Sheets Nos. 1, 17, 21, and 35.)
54
48
42
36
30
24
18
12
6
Voltage Amplification
1
2
3
4
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second

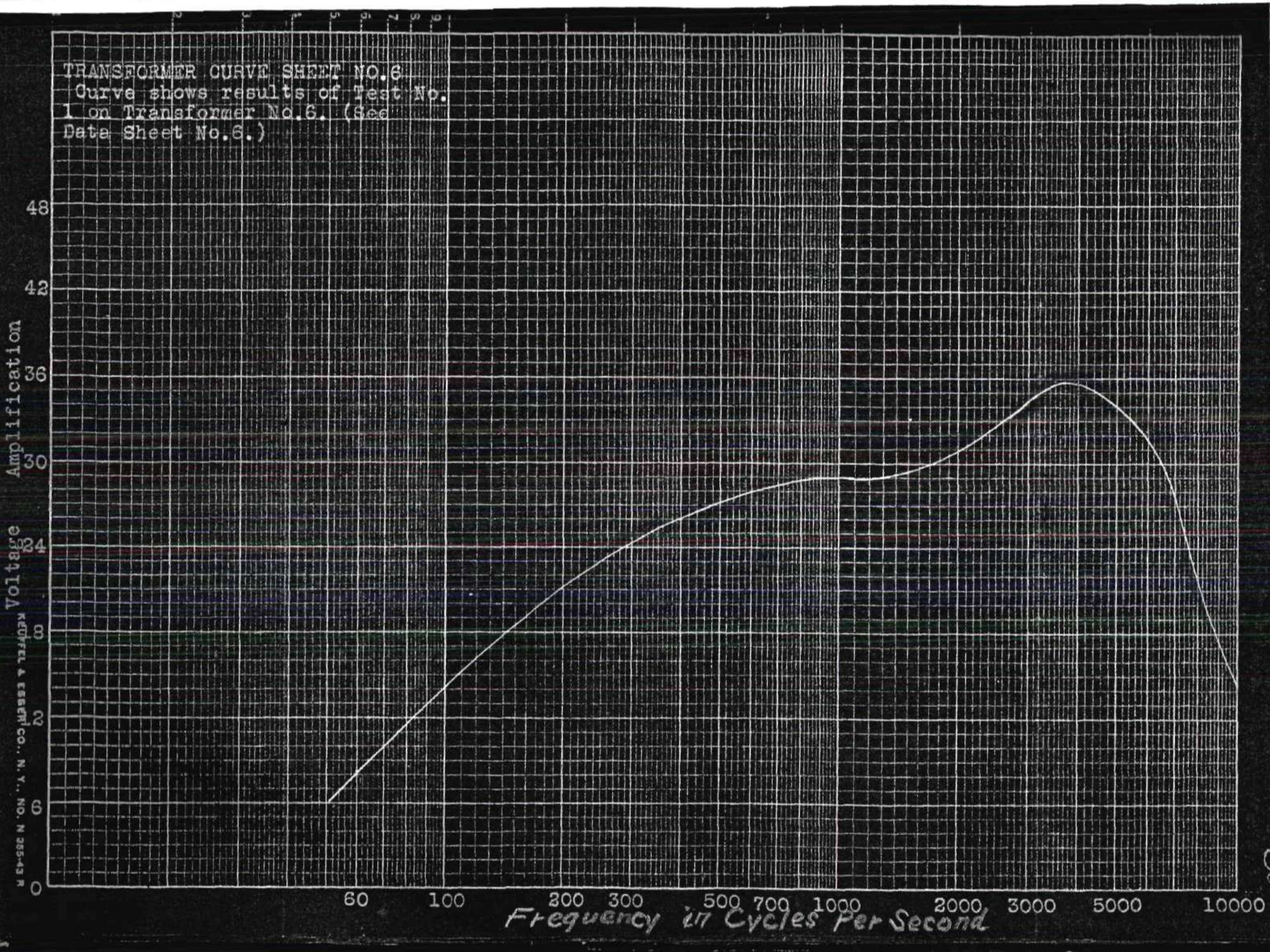

CURVE SHEET NO. 2
Curves No.1,2,3 and 4 show respectively the results of Test No.1 on Transformers No. 2,18,35 and 42. Curve No.5 shows results of Test No.10 on Transformer No.2. (See Data Sheets Nos.4,18,39,46 and 75 respectively.)
Voltage Amplification
48
42
36
30
24
18
12
6
0
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
1
2
3
4
5
KEUFFEL & ESSER CO., N. Y. NO. N 355-43 R


TRANSFORMER CURVE SHEET NO.3
Curve No.1 shows results of Test No.1 on Transformer No.3.
Curve No.2 shows results of Test No.1 on Transformer No.5.
(See Data Sheets Nos.3 and 5 respectively.)
Voltage Amplification
0
6
12
18
24
30
36
42
48
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles Per Second
1
2
KEUFFEL & ESSER CO., N.Y., NO. N 355-43 R

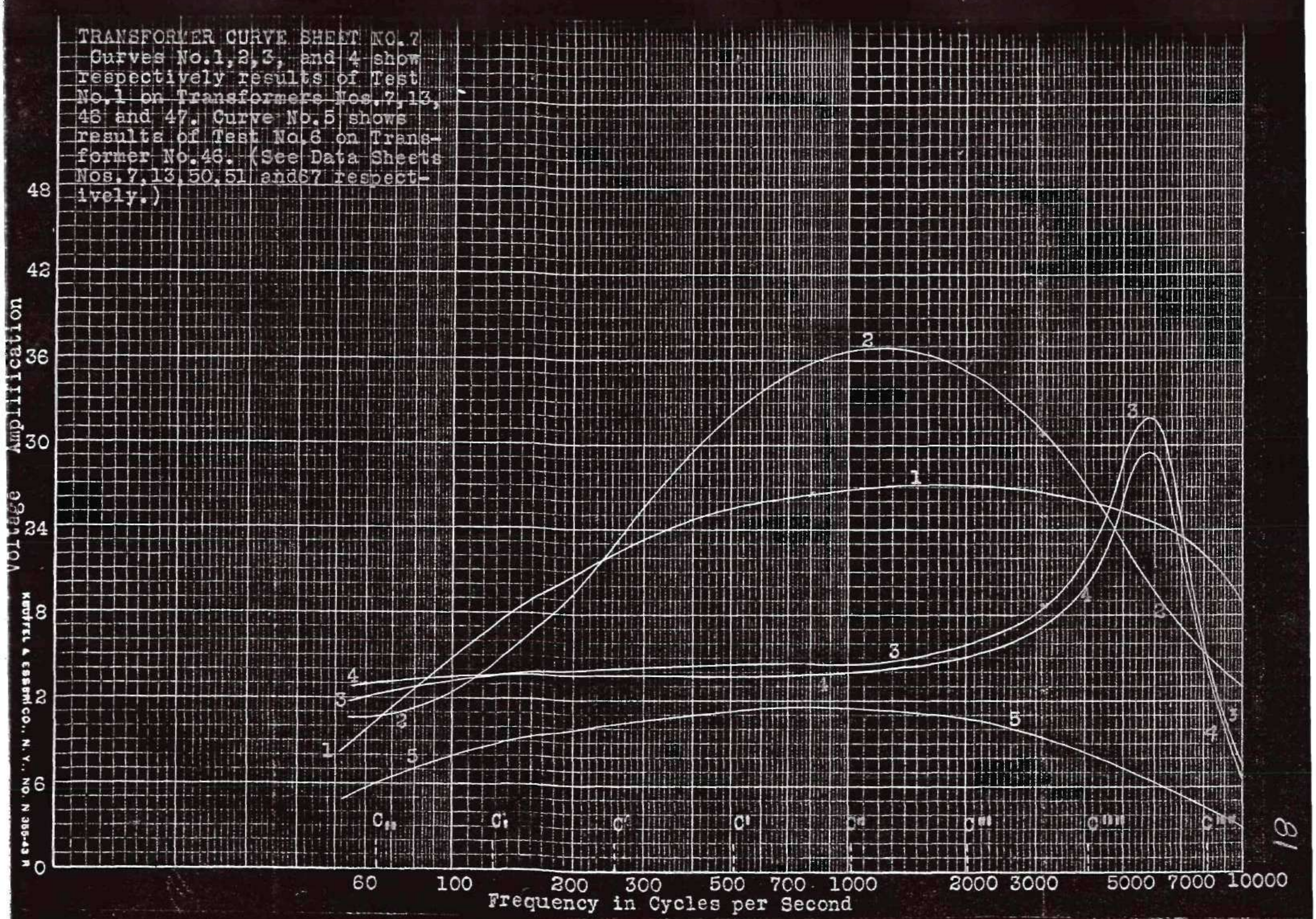

TRANSFORMER CURVE SHEET NO.4
Curve shows results of Test No.1 on Transformer No.4. (See Data Sheet No.2.)
Voltage Amplification
0
6
12
18
24
30
36
42
48
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
KEUFFEL & ESSER CO., N.Y. NO. N 355-43 R

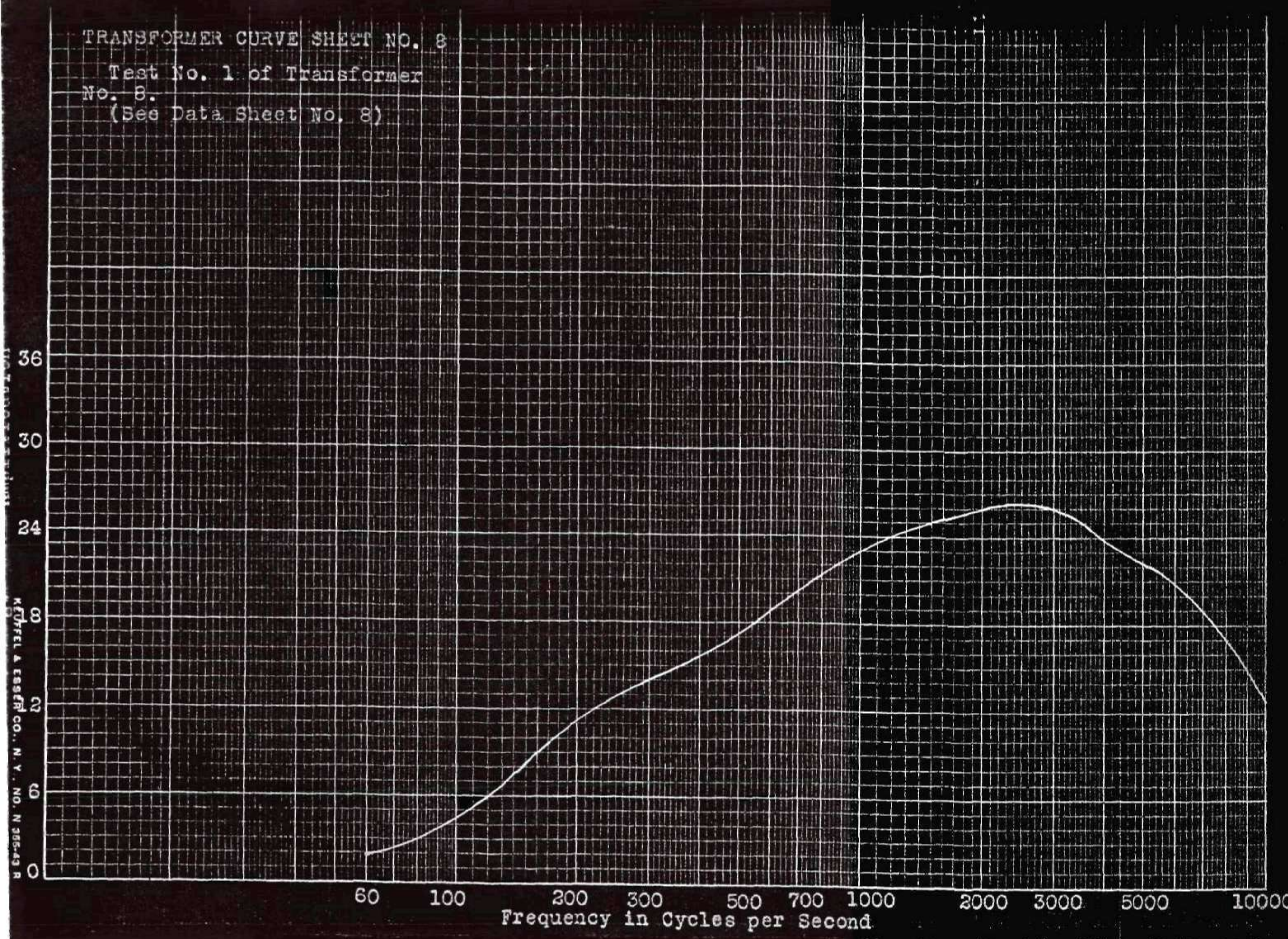


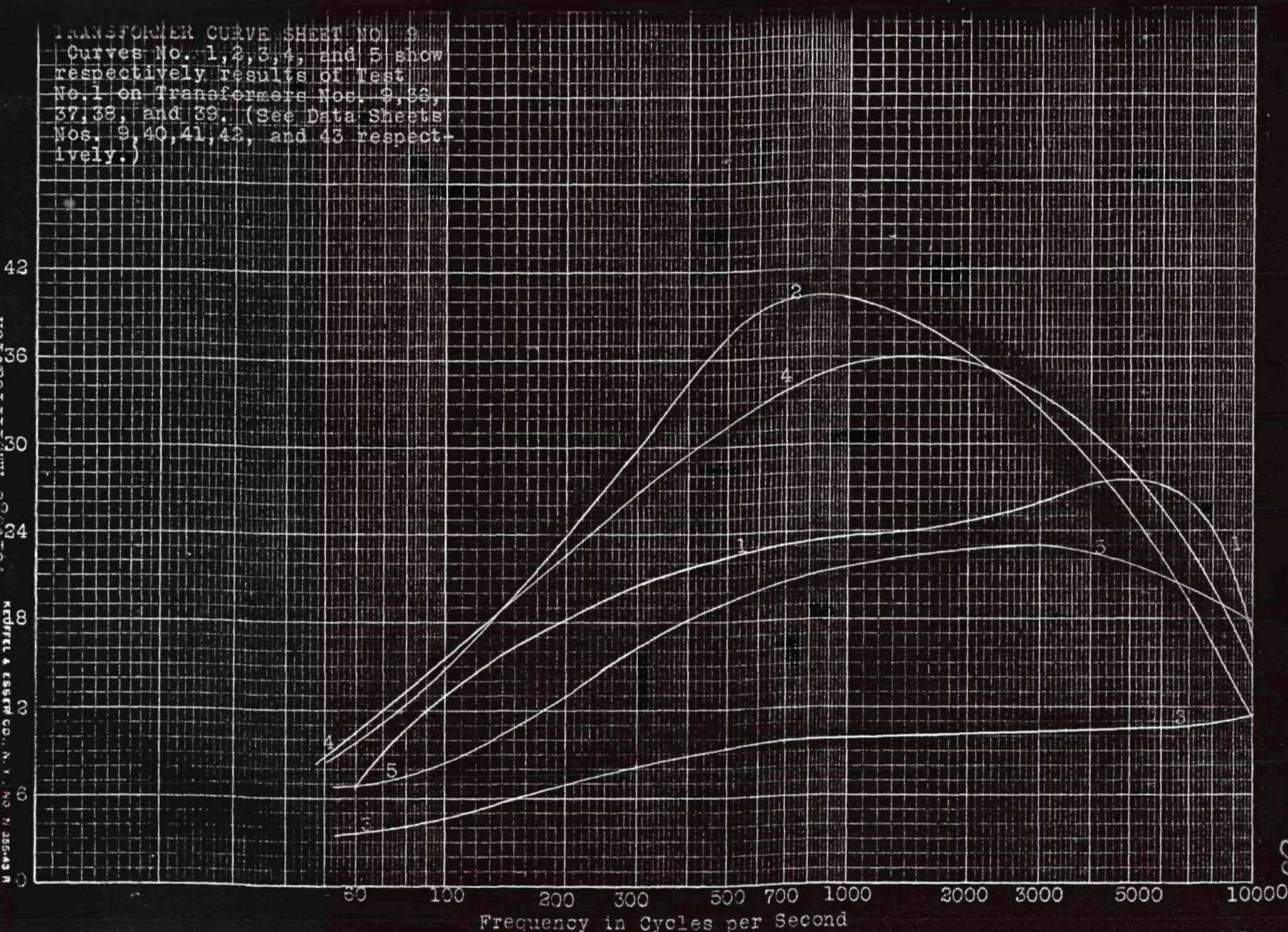
TRANSFORMER CURVE SHEET NO.5
Curves Nos.1,2 and3 show respectively results of Test No.1 on Transformers Nos.34, 44 and 57. (See Data Sheets Nos.38,48 and 78 respectively.)
48
42
36
30
24
18
12
6
0
1
2
3
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second



TRANSFORMER CURVE SHEET NO.6
Curve shows results of Test No. 1 on Transformer No.6. (See Data Sheet No.6.)
Voltage Amplification
48
42
36
30
24
18
12
6
0
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles Per Second
KEUFFEL & ESSER CO., N.Y., NO. N 365-43 R

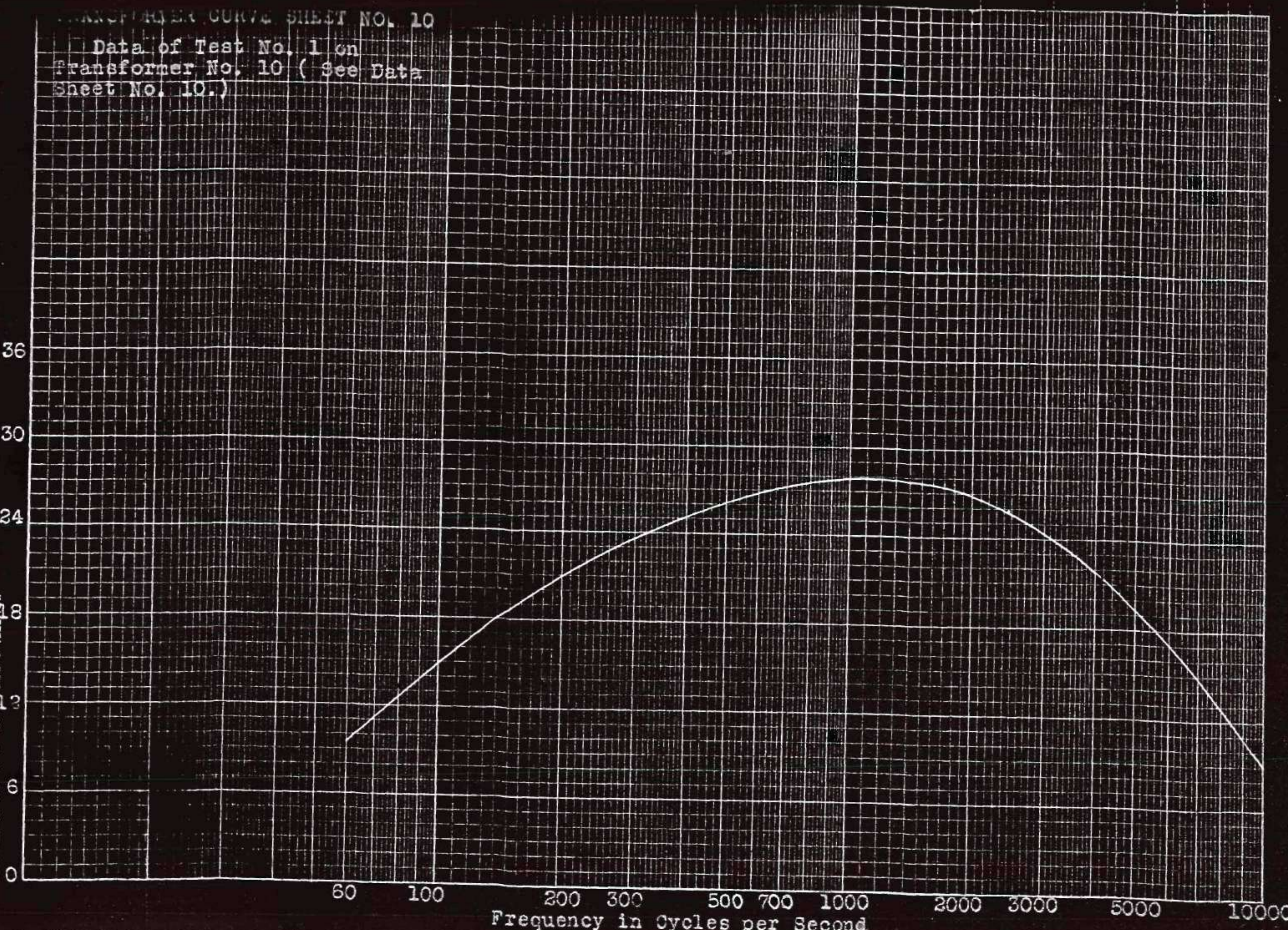

TRANSFORMER CURVE SHEET NO.7
Curves No.1,2,3, and 4 show respectively results of Test No.1 on Transformers Nos.7,13, 46 and 47. Curve No.5 shows results of Test No.6 on Transformer No.46. (See Data Sheets Nos.7,13,50,51 and67 respectively.)
Voltage Amplification
0
6
12
18
24
30
36
42
48
60
100
200
300
500
700
1000
2000
3000
5000
7000
10000
Frequency in Cycles per Second
KEUFFEL & ESSER CO. N.Y. NO. N 355-43 R
18

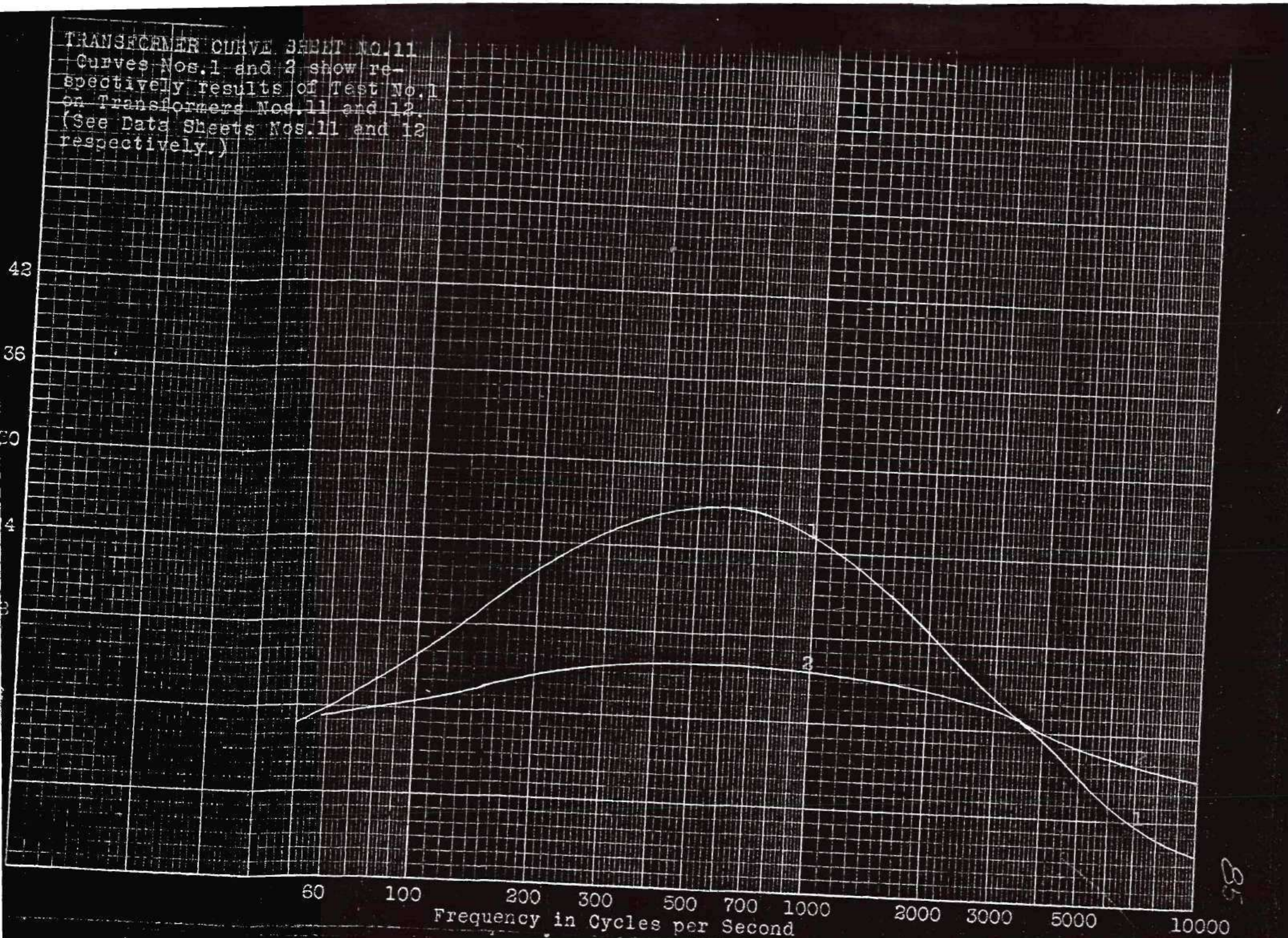

TRANSFORMER CURVE SHEET NO. 8
Test No. 1 of Transformer No. 8.
(See Data Sheet No. 8)
36
30
24
18
12
6
0
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
KEUFFEL & ESSER CO., N.Y. NO. N 355-43 R

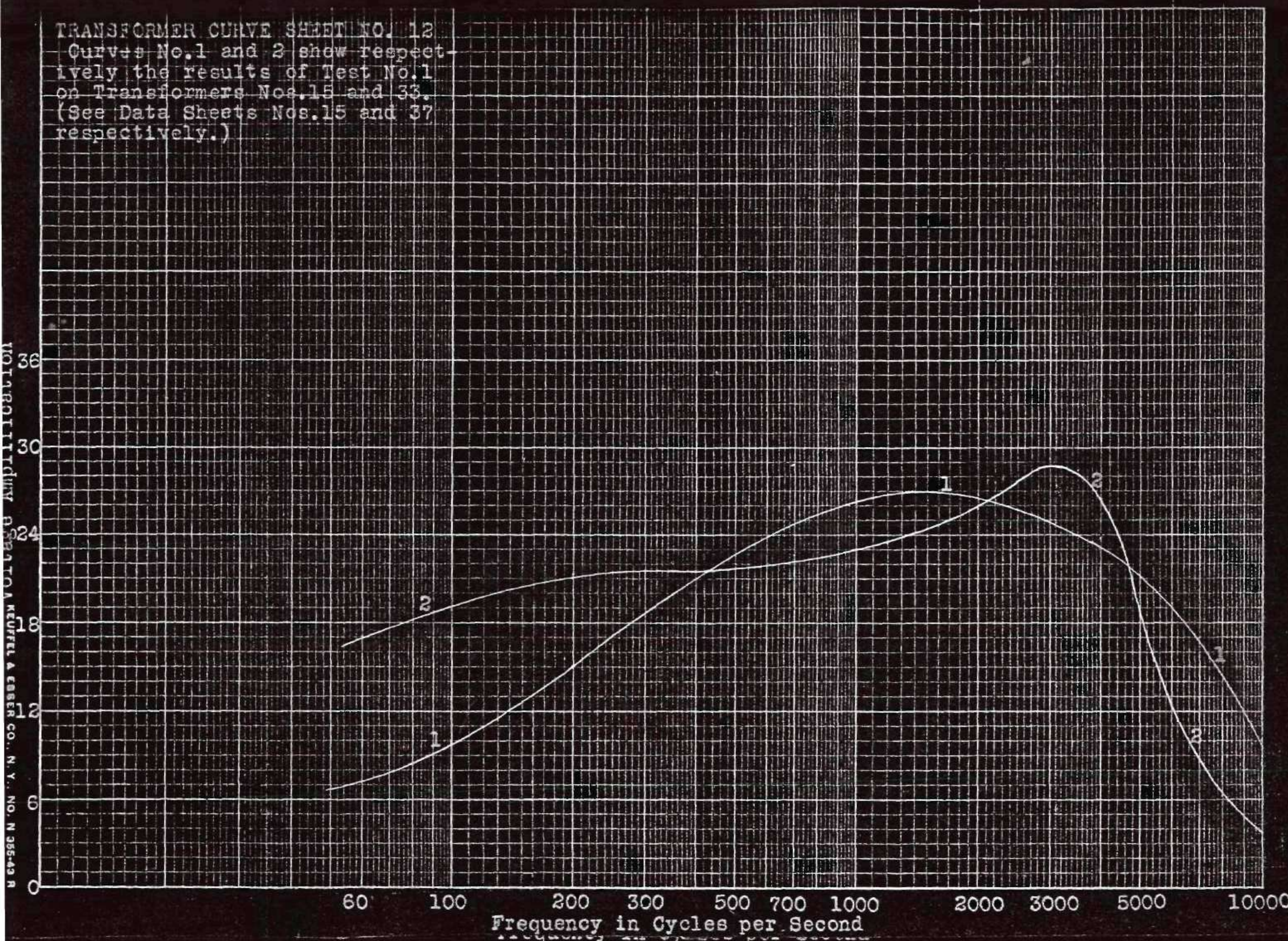


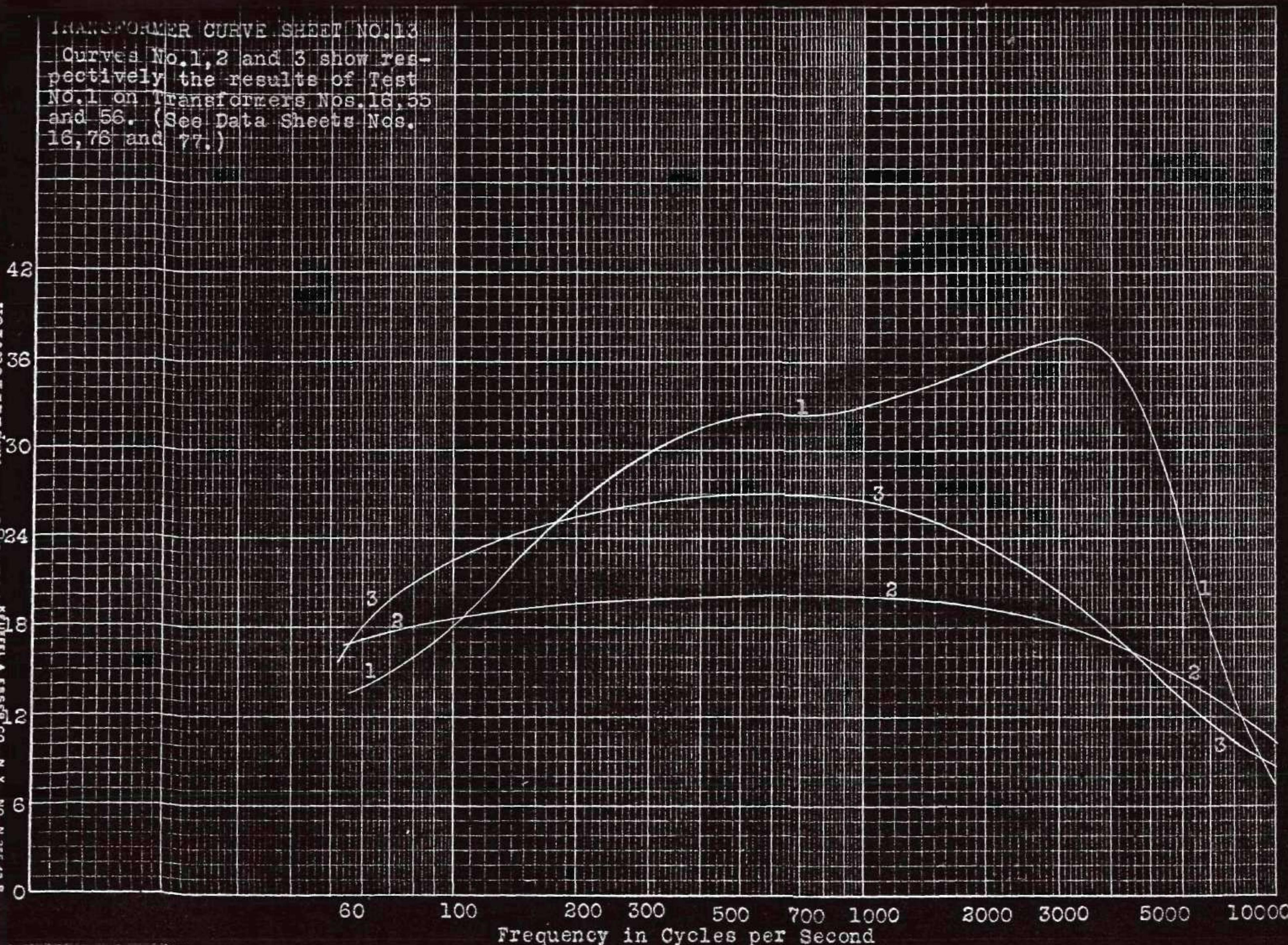
TRANSFORMER CURVE SHEET NO. 9
Curves No. 1,2,3,4, and 5 show respectively results of Test No.1 on Transformers Nos. 9,36, 37,38, and 39. (See Data Sheets Nos. 9,40,41,42, and 43 respectively.)
VOLTAGE AMPLIFICATION
42
36
30
24
8
2
6
0
1
2
3
4
5
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
KEUFFEL & ESSER CO., N. Y. NO. 359-43 R

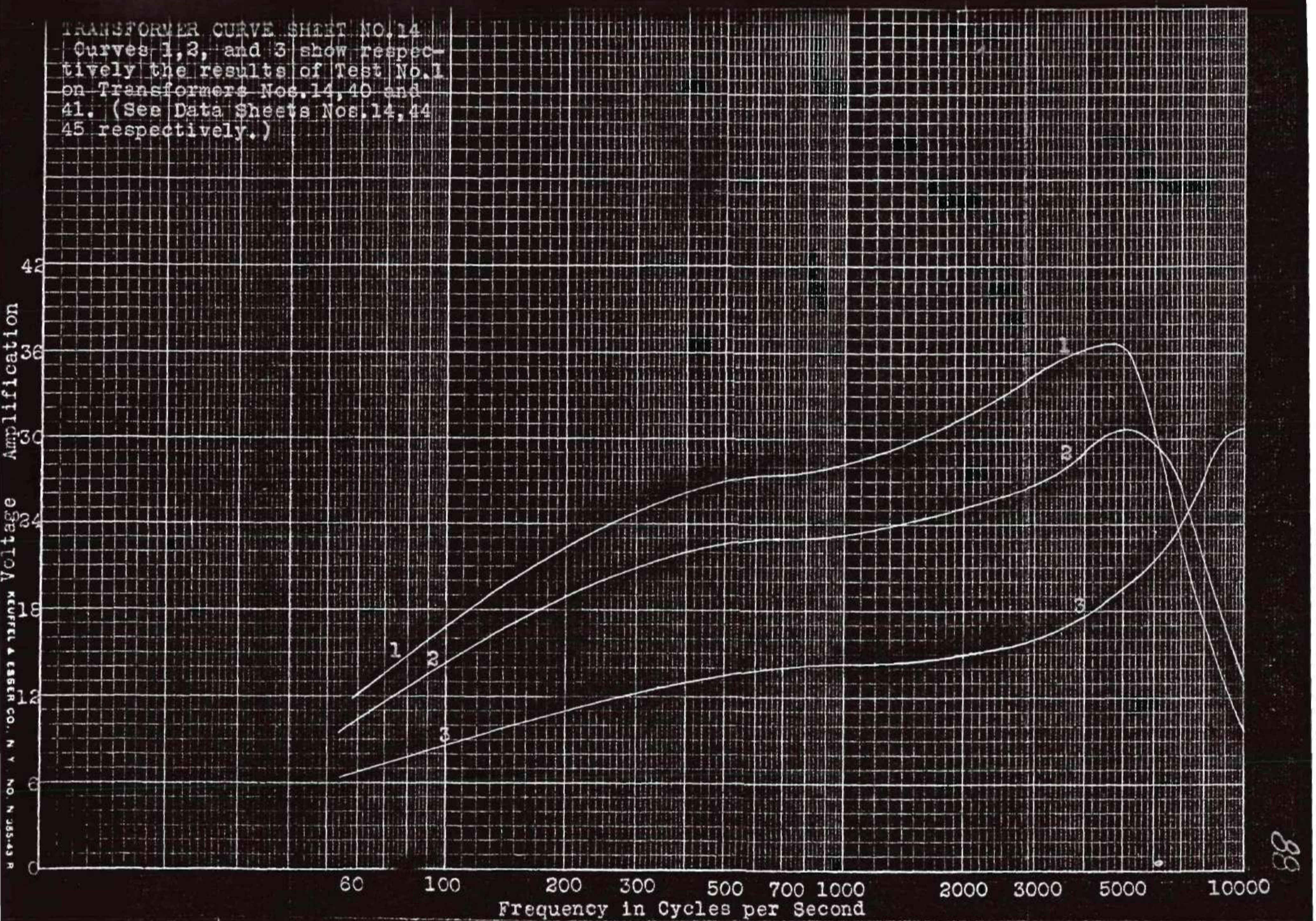
83

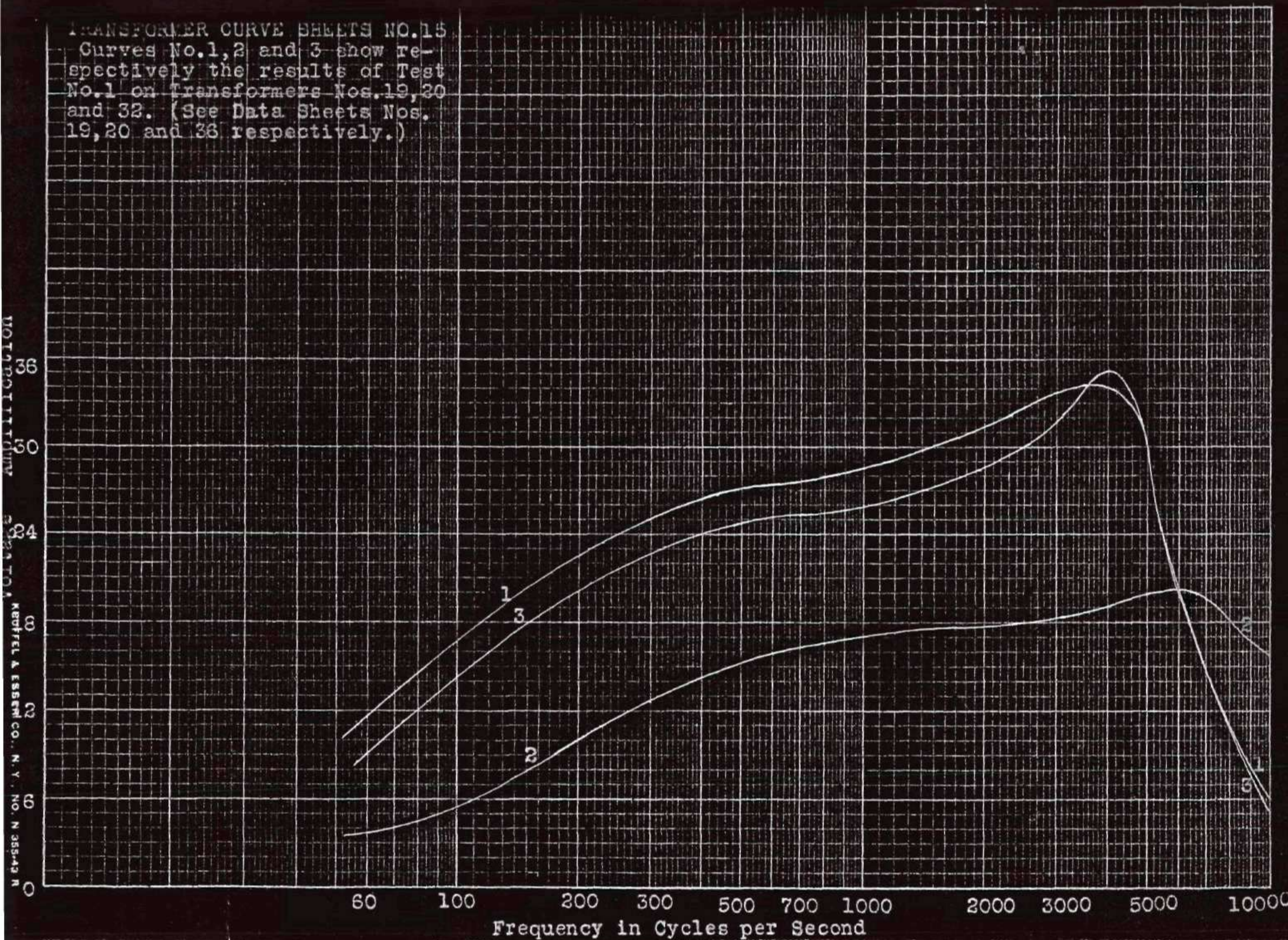

CURVE SHEET NO. 10
Data of Test No. 1 on
Transformer No. 10 (See Data
Sheet No. 10.)
36
30
24
18
6
0
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
KEUFFEL & ESSER CO., N. Y. NO. N 366-43 R

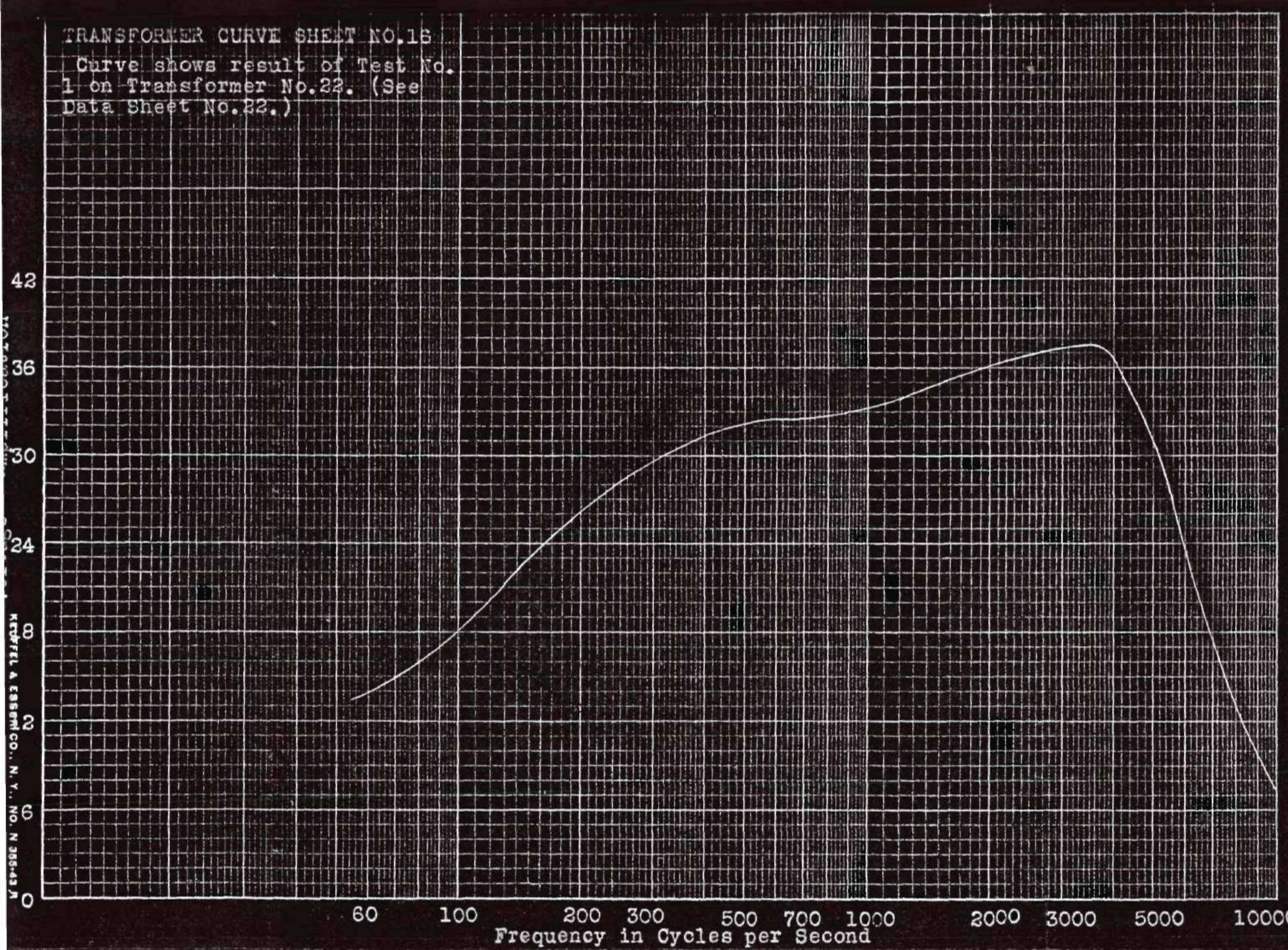

TRANSFORMER CURVE SHEET NO.11
Curves Nos.1 and 2 show respectively results of Test No.1 on Transformers Nos.11 and 12. (See Data Sheets Nos.11 and 12 respectively.)
42
36
1
2
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second

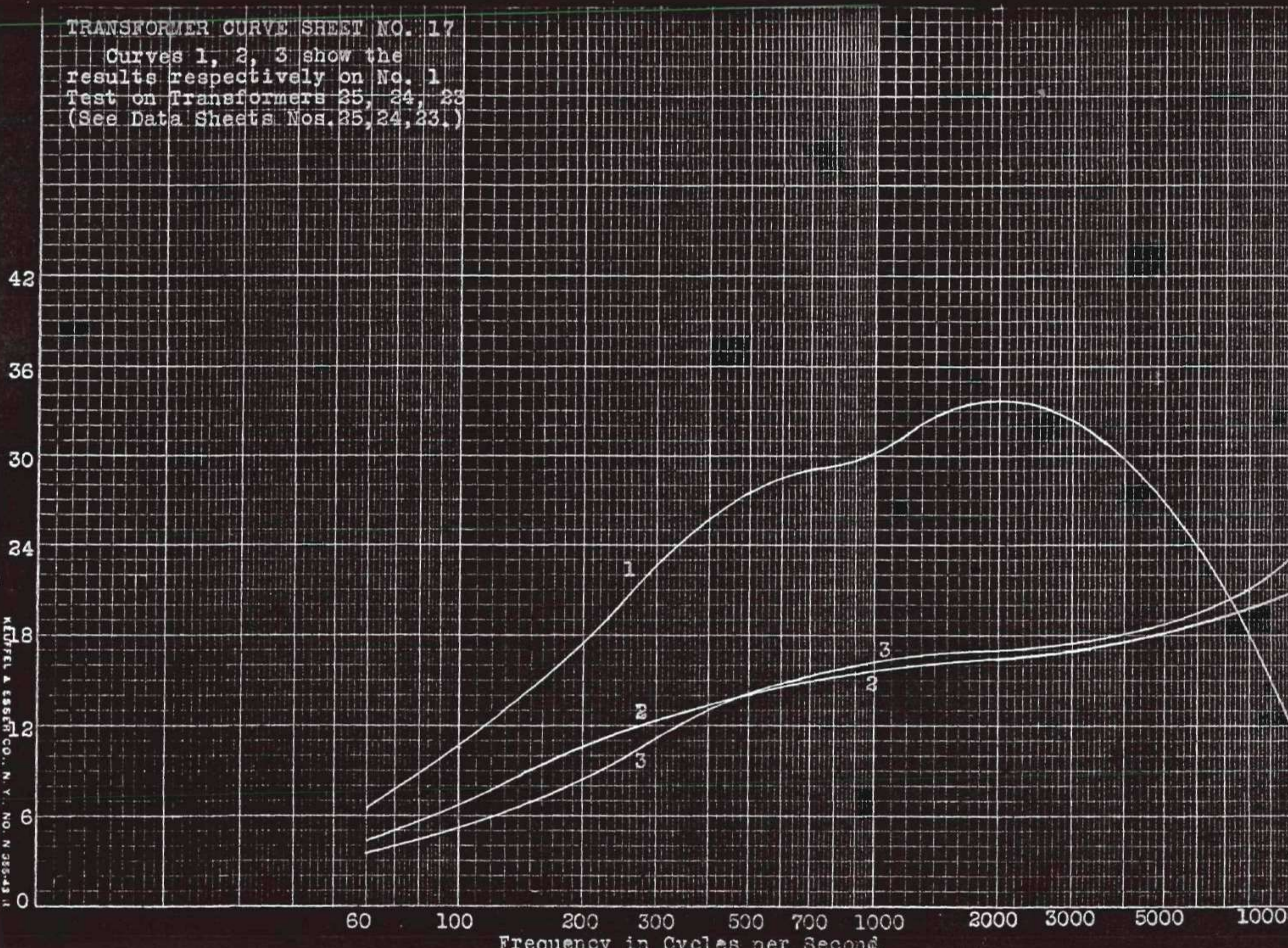

TRANSFORMER CURVE SHEET NO. 12
Curves No.1 and 2 show respectively the results of Test No.1 on Transformers Nos.15 and 33. (See Data Sheets Nos.15 and 37 respectively.)
VOLTAGE AMPLIFICATION
0
6
12
18
24
30
36
1
2
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
KEUFFEL & ESSER CO., N.Y. NO. N 365-43 R


TRANSFORMER CURVE SHEET NO.13
Curves No.1,2 and 3 show respectively the results of Test No.1 on Transformers Nos.16,55 and 56. (See Data Sheets Nos. 16,76 and 77.)
42
36
30
24
18
12
6
0
1
2
3
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second

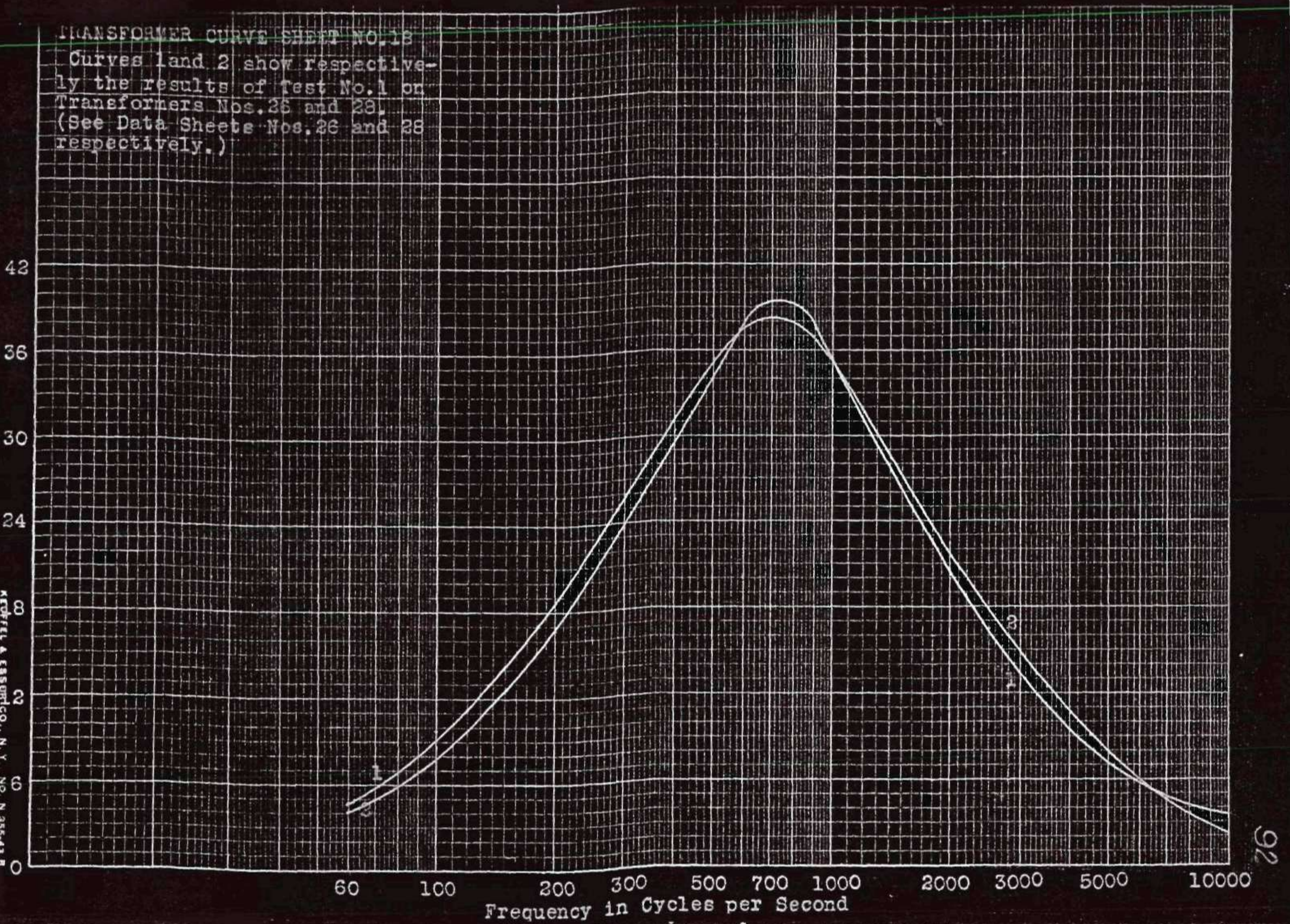

TRANSFORMER CURVE SHEET NO.14
Curves 1,2, and 3 show respectively the results of Test No.1 on Transformers Nos.14,40 and 41. (See Data Sheets Nos.14,44 45 respectively.)
Voltage Amplification
0
6
12
18
24
30
36
42
1
2
3
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
KEUFFEL & ESSER CO., N. Y. NO. N 385-43 R

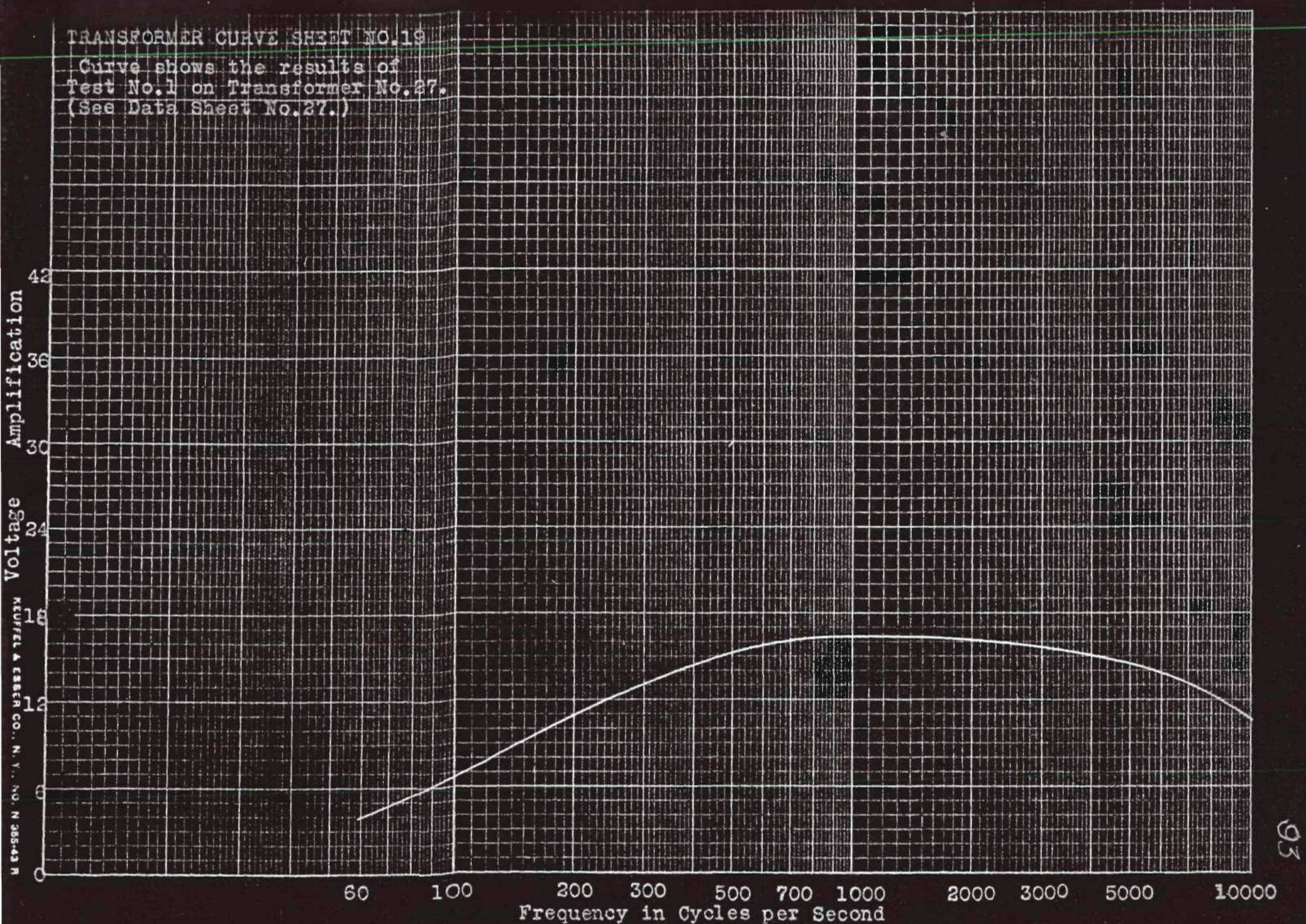

TRANSFORMER CURVE SHEETS NO.15
Curves No.1,2 and 3 show respectively the results of Test No.1 on Transformers Nos.19,20 and 32. (See Data Sheets Nos. 19,20 and 36 respectively.)
36
30
24
18
12
6
0
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
1
2
3


TRANSFORMER CURVE SHEET NO.16
Curve shows result of Test No. 1 on Transformer No.22. (See Data Sheet No.22.)
42
36
30
24
18
12
6
0
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second

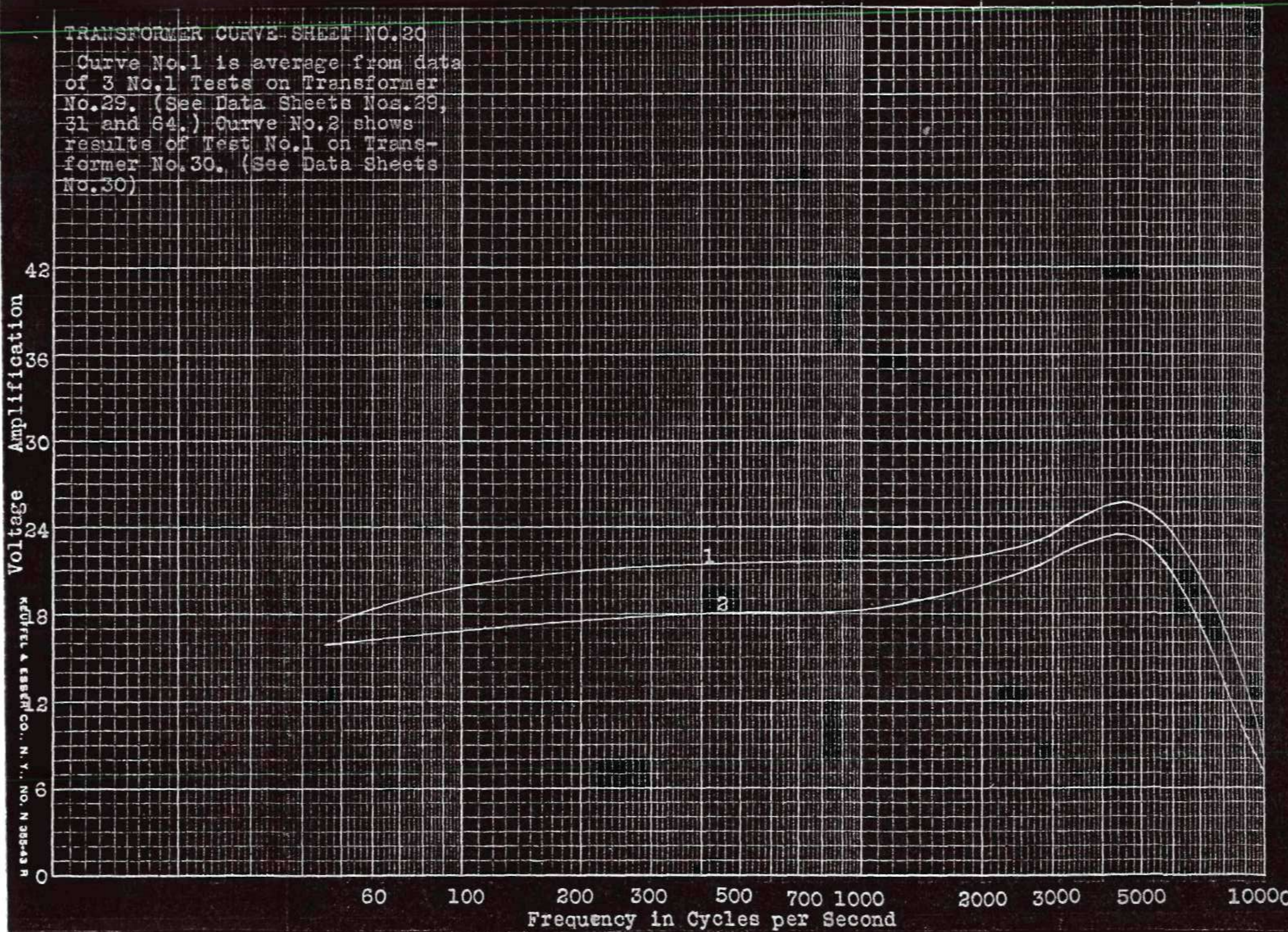

TRANSFORMER CURVE SHEET NO. 17
Curves 1, 2, 3 show the results respectively on No. 1 Test on Transformers 25, 24, 23
(See Data Sheets Nos. 25, 24, 23.)
42
36
30
24
18
12
6
0
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
1
2
3
3
2
KEUFFEL & ESSER CO., N. Y. NO. N 355-43 II

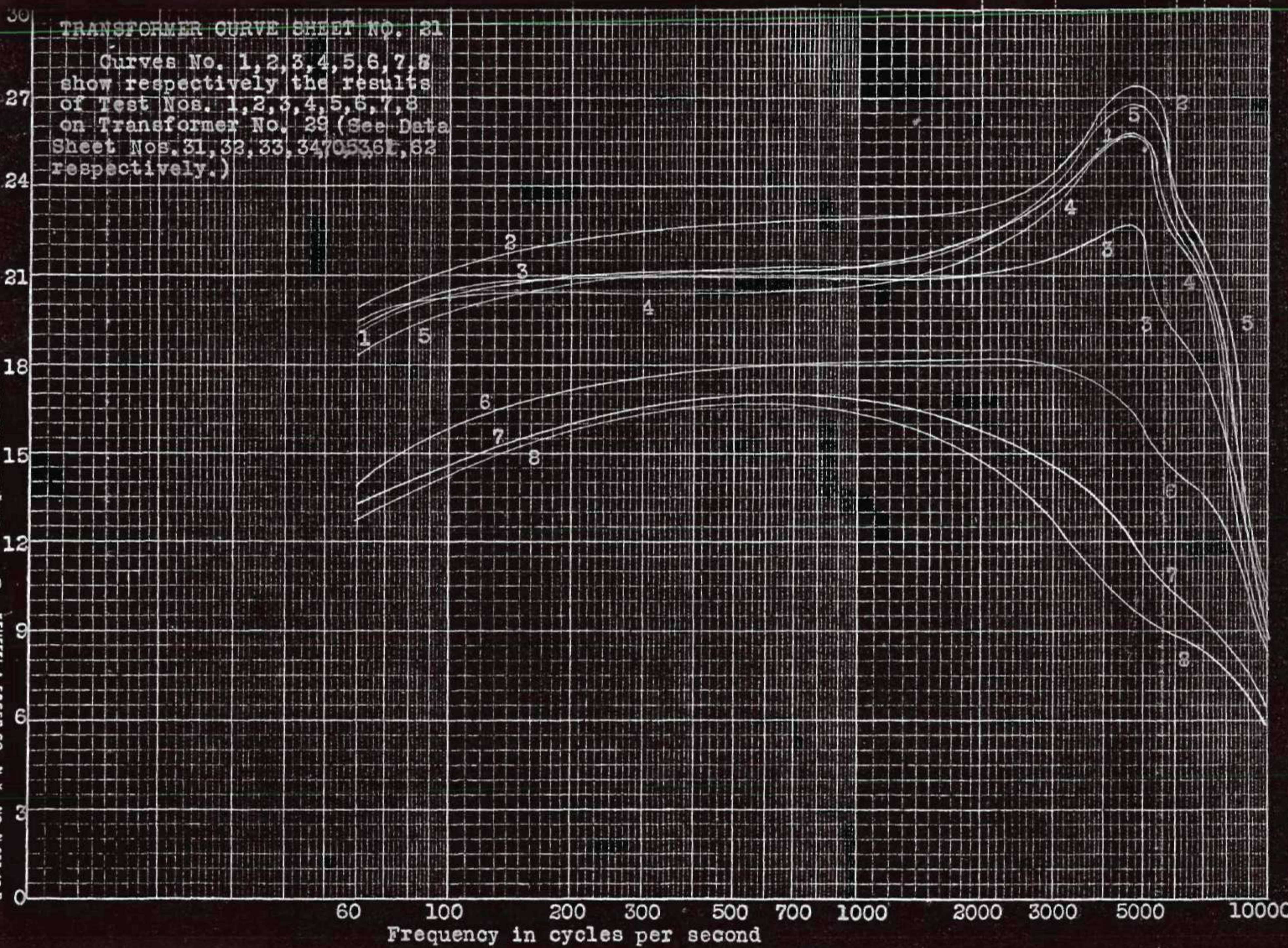
16


TRANSFORMER CURVE SHEET NO.18
Curves 1and 2 show respectively the results of Test No.1 on Transformers Nos.26 and 28.
(See Data Sheets Nos.26 and 28 respectively.)
42
36
30
24
18
12
6
0
1
2
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second

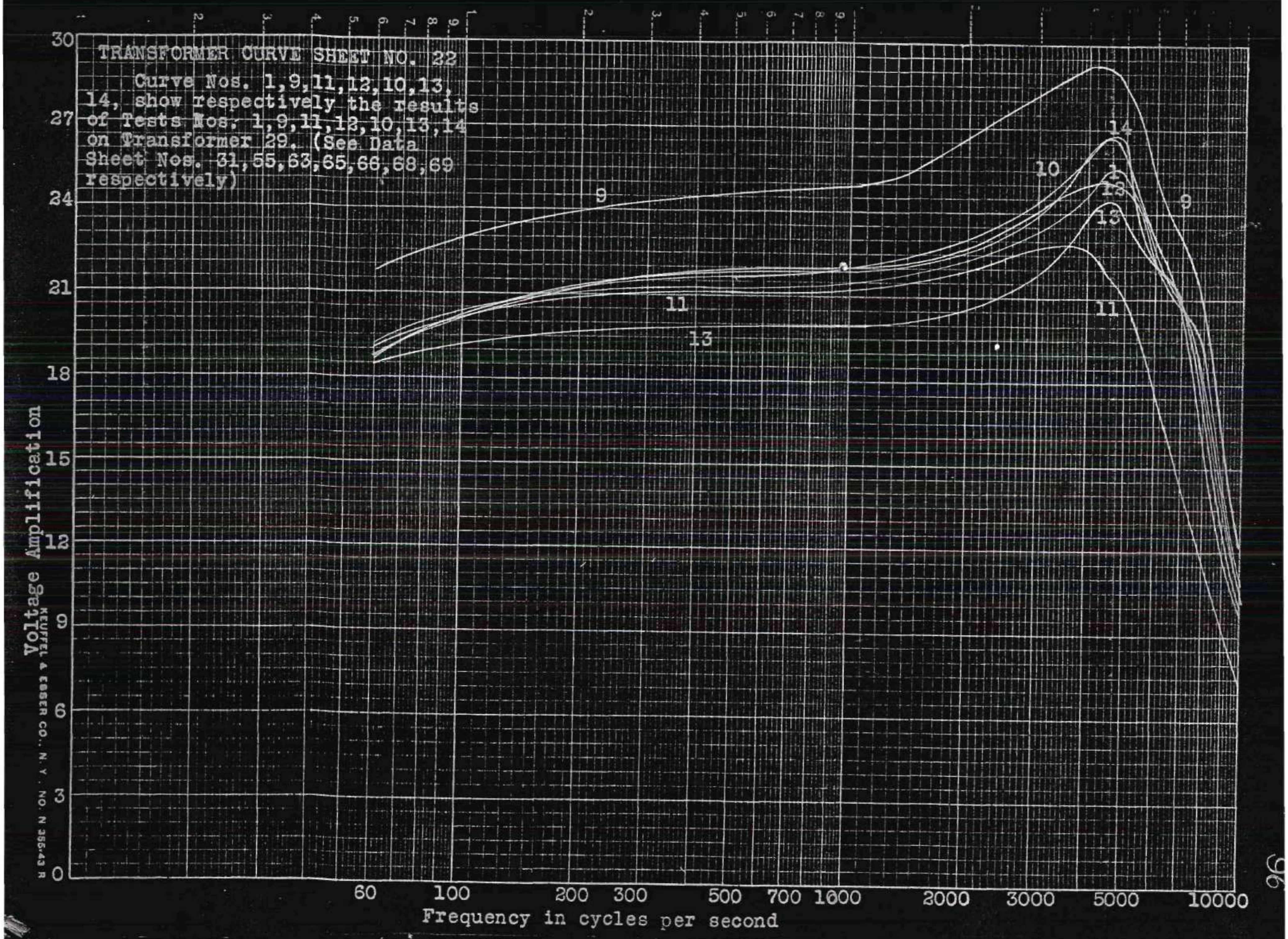


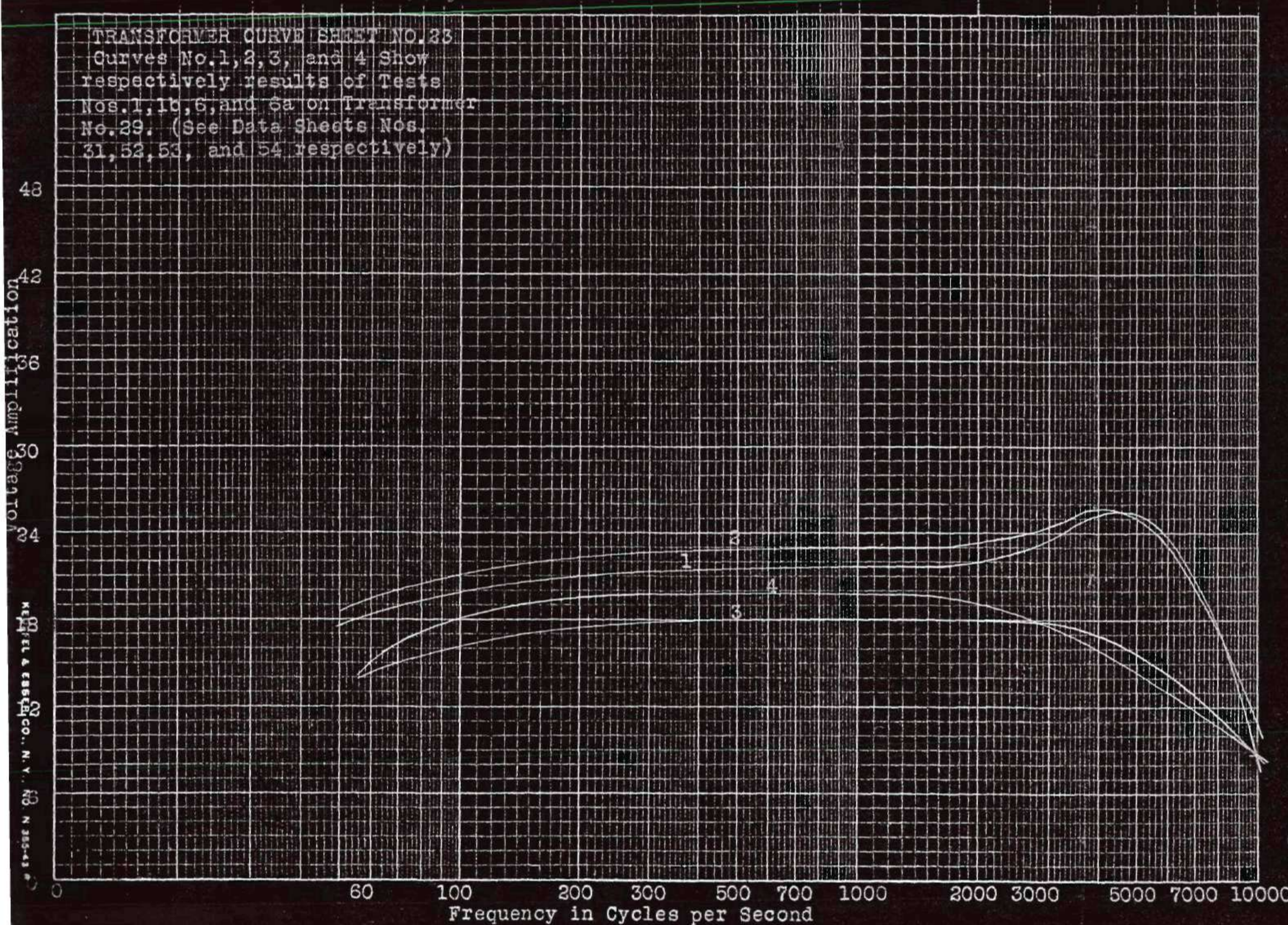
TRANSFORMER CURVE SHEET NO.19
Curve shows the results of
Test No.1 on Transformer No.27.
(See Data Sheet No.27.)
Voltage Amplification
42
36
30
24
18
12
6
0
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
KEUFFEL & ESSER CO., N.Y. NO. N 355-43 R

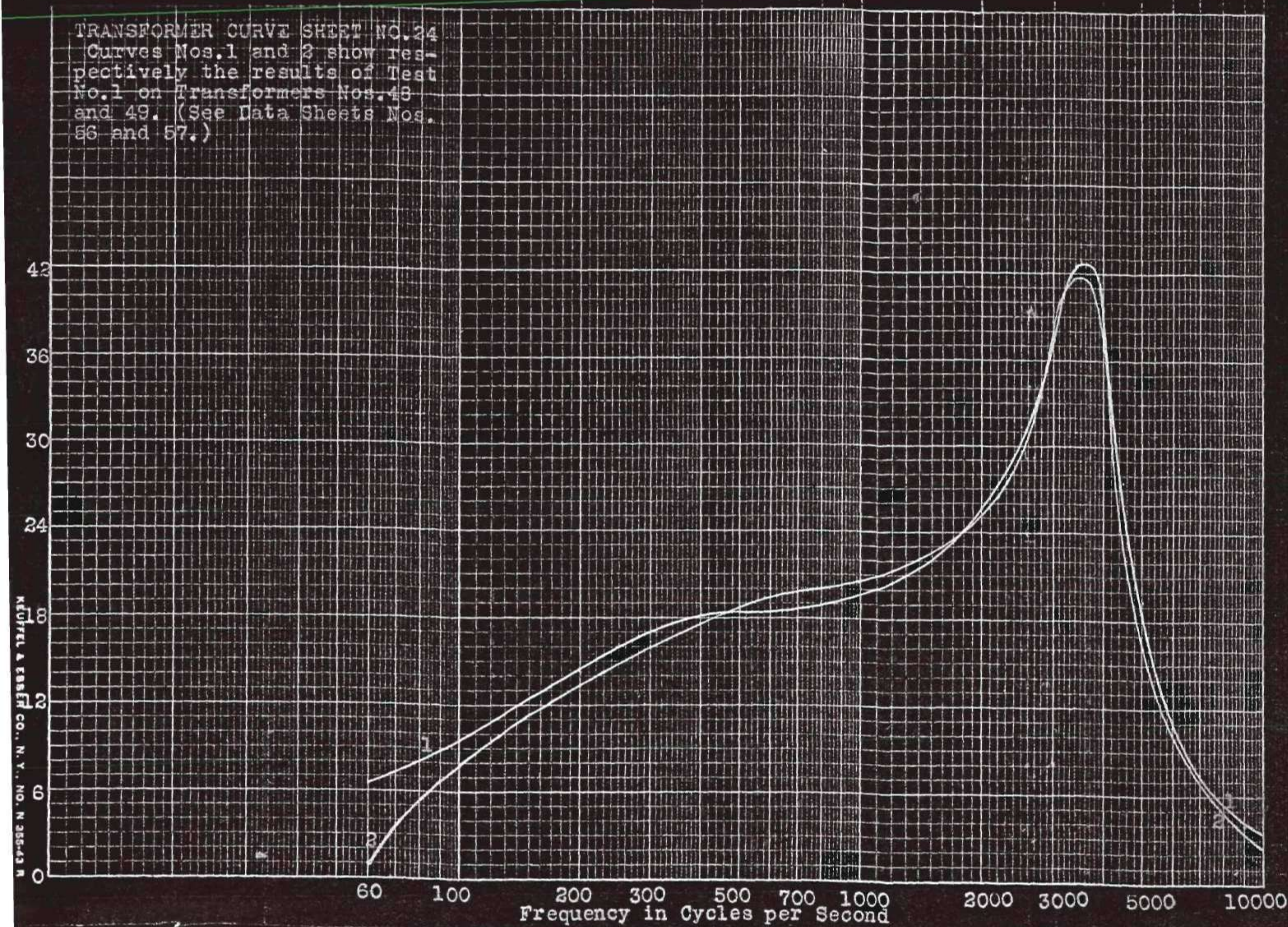

TRANSFORMER CURVE SHEET NO.20
Curve No.1 is average from data of 3 No.1 Tests on Transformer No.29. (See Data Sheets Nos.29, 31 and 64.) Curve No.2 shows results of Test No.1 on Transformer No.30. (See Data Sheets No.30)
Voltage Amplification
42
36
30
24
18
12
6
0
1
2
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
KEUFFEL & ESSER CO., N. Y., NO. N 355-43 R

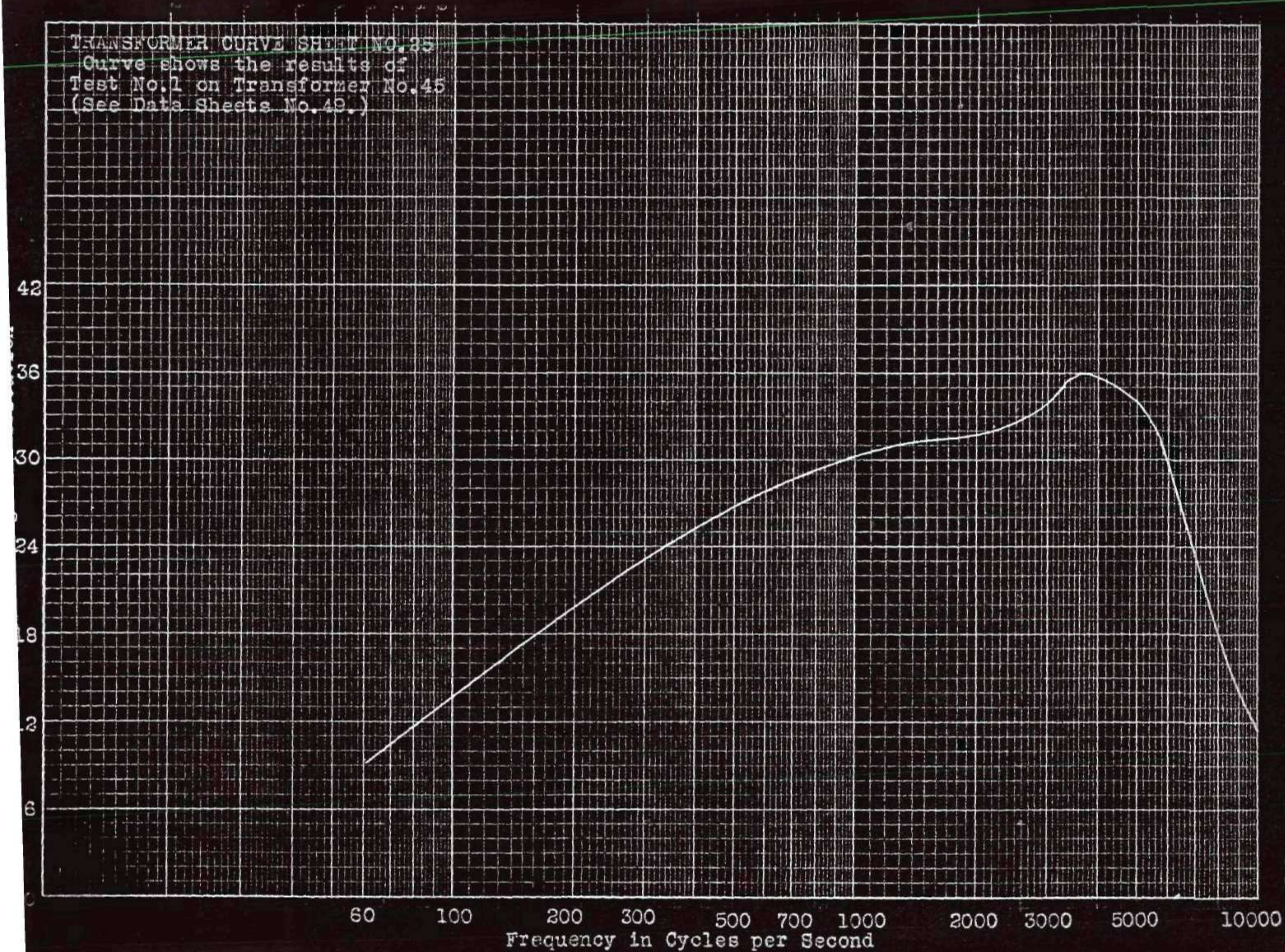


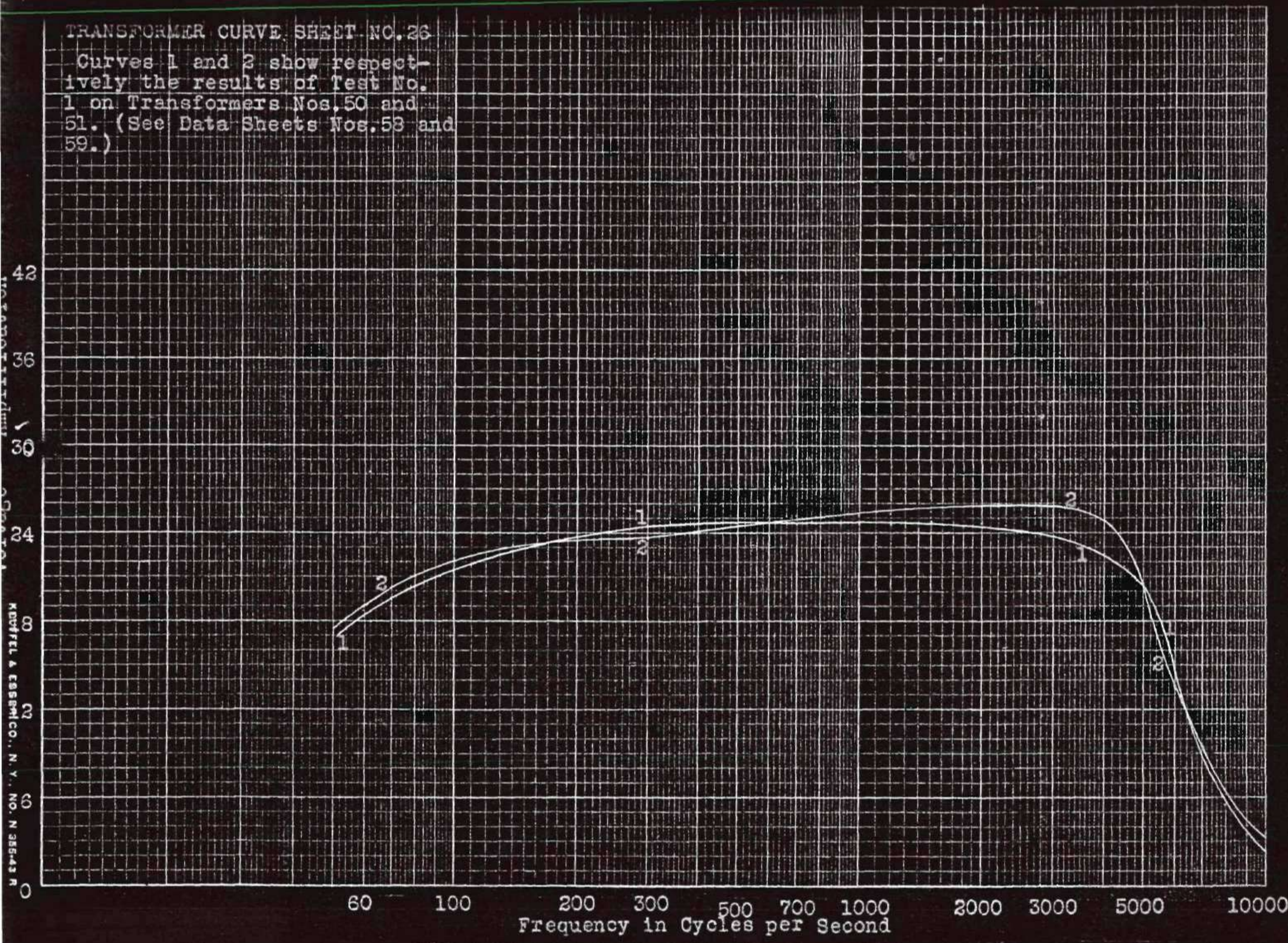
TRANSFORMER CURVE SHEET NO. 21
Curves No. 1,2,3,4,5,6,7,8 show respectively the results of Test Nos. 1,2,3,4,5,6,7,8 on Transformer No. 29 (See Data Sheet Nos. 31,32,33,34,35,36,61,62 respectively.)
Voltage Amplification
Frequency in cycles per second
0
3
6
9
12
15
18
21
24
27
30
60
100
200
300
500
700
1000
2000
3000
5000
10000
1
2
3
4
5
6
7
8
KEUFFEL & ESSER CO., N.Y. NO. N 355-43 R


TRANSFORMER CURVE SHEET NO. 22
Curve Nos. 1,9,11,12,10,13, 14, show respectively the results of Tests Nos. 1,9,11,12,10,13,14 on Transformer 29. (See Data Sheet Nos. 31,55,63,65,66,68,69 respectively)
Voltage Amplification
Frequency in cycles per second
KEUFFEL & ESSER CO., N.Y. NO. N 355-43 R

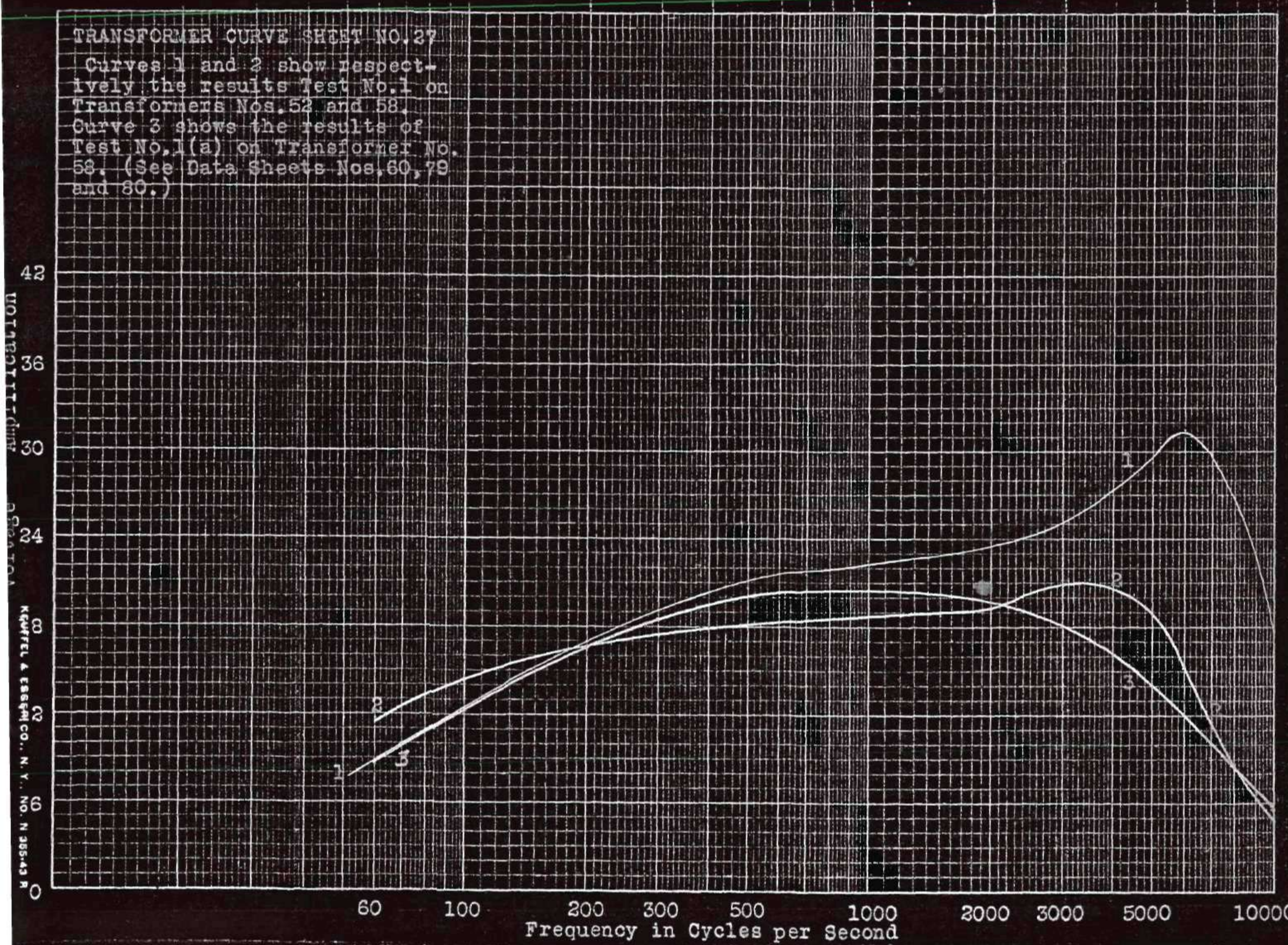

TRANSFORMER CURVE SHEET NO.23
Curves No.1,2,3, and 4 Show
respectively results of Tests
Nos.1,1b,6,and 6a on Transformer
No.29. (See Data Sheets Nos.
31,52,53, and 54 respectively)
Voltage Amplification
48
42
36
30
24
18
12
6
0
60
100
200
300
500
700
1000
2000
3000
5000
7000
10000
Frequency in Cycles per Second
1
2
3
4
KEUFFEL & ESSER CO., N.Y. NO. N 355-41

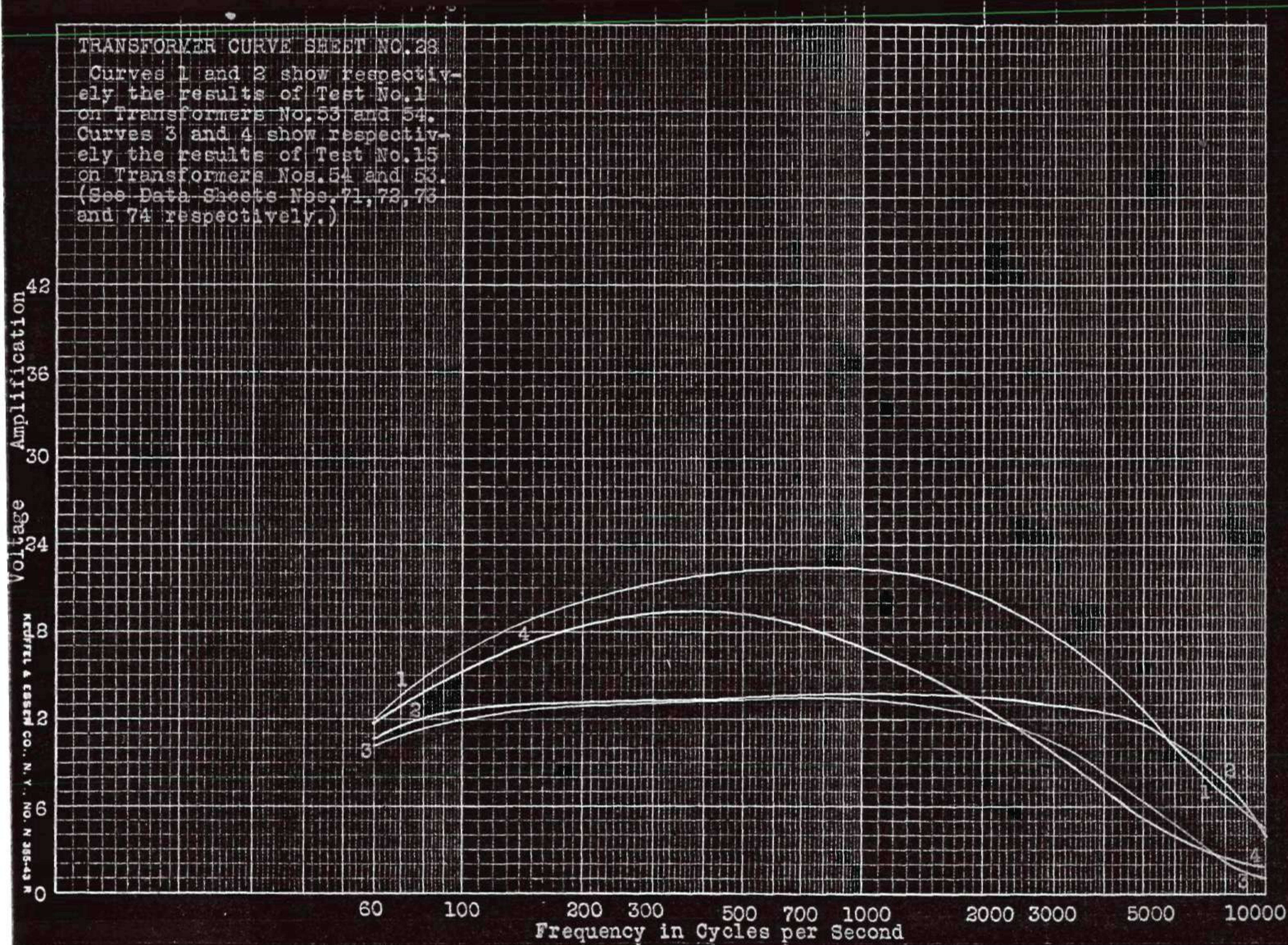

TRANSFORMER CURVE SHEET NO.24
Curves Nos.1 and 2 show respectively the results of Test No.1 on Transformers Nos.48 and 49. (See Data Sheets Nos. 56 and 57.)
0
6
12
18
24
30
36
42
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
1
2

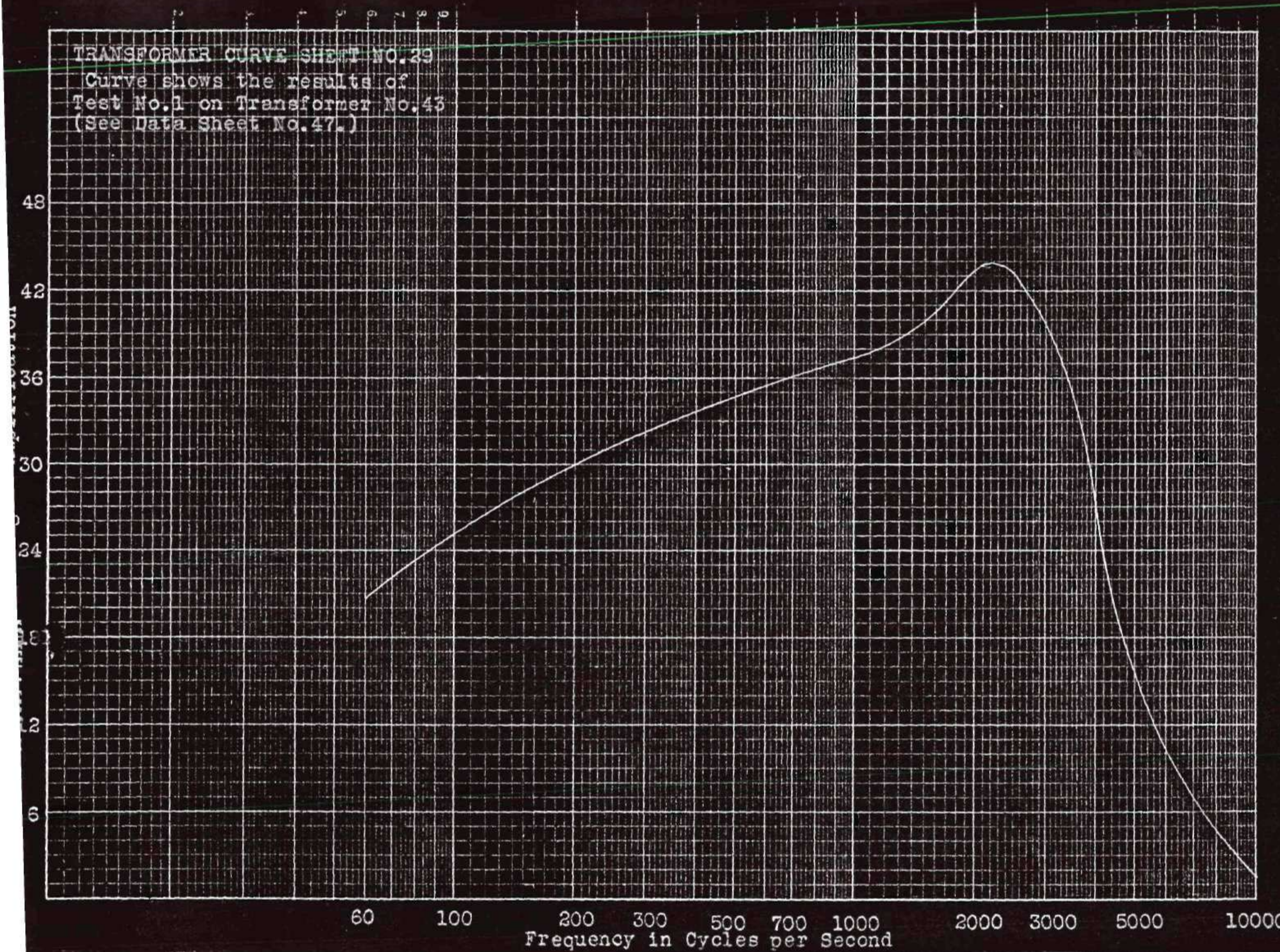

TRANSFORMER CURVE SHEET NO.25
Curve shows the results of
Test No.1 on Transformer No.45
(See Data Sheets No.49.)
42
36
30
24
18
6
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second

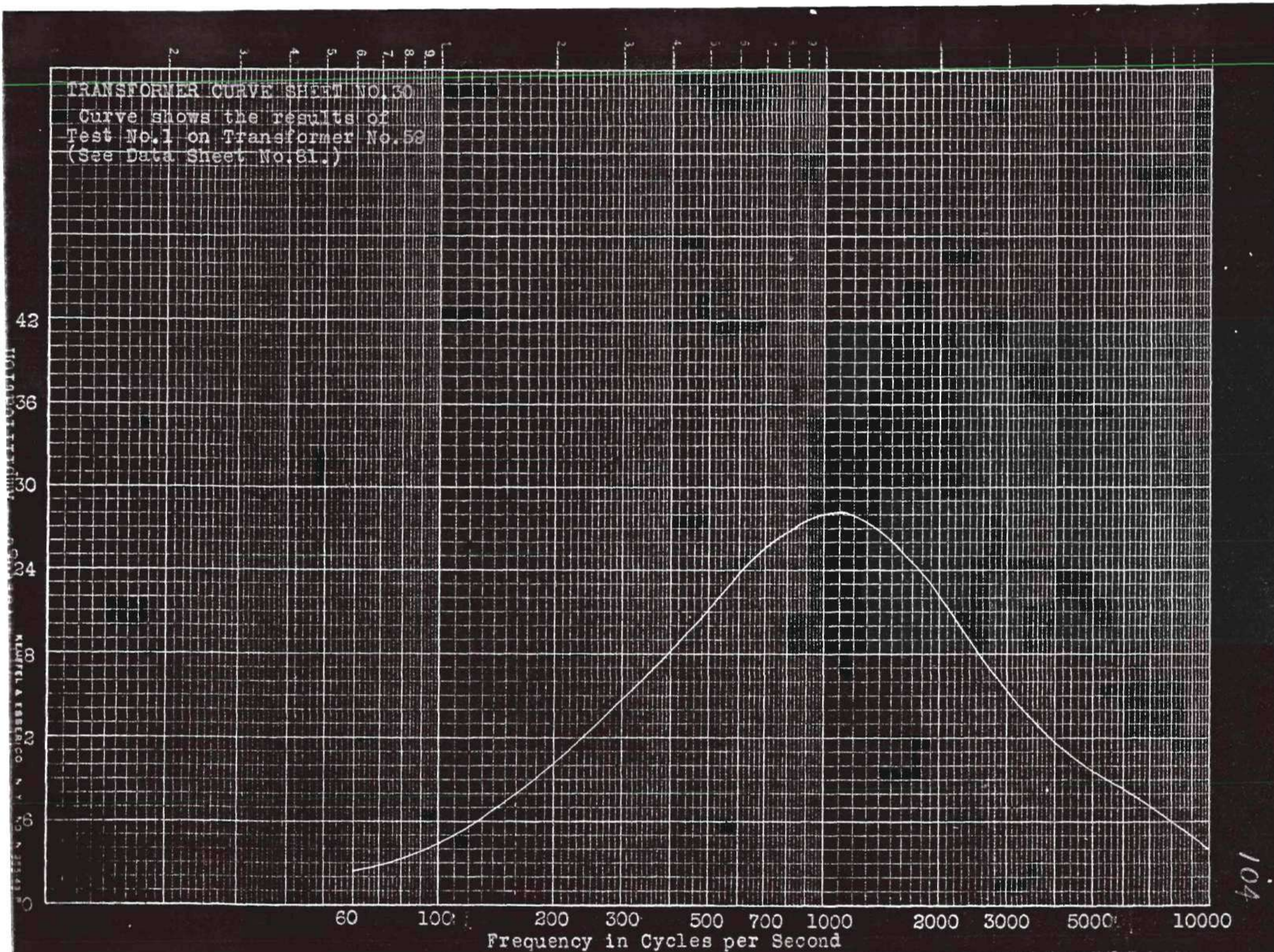


TRANSFORMER CURVE SHEET NO. 26
Curves 1 and 2 show respectively the results of Test No. 1 on Transformers Nos. 50 and 51. (See Data Sheets Nos. 58 and 59.)
42
36
30
24
18
12
6
0
1
2
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
KEUFFEL & ESSER CO., N. Y., NO. N 355-43 R

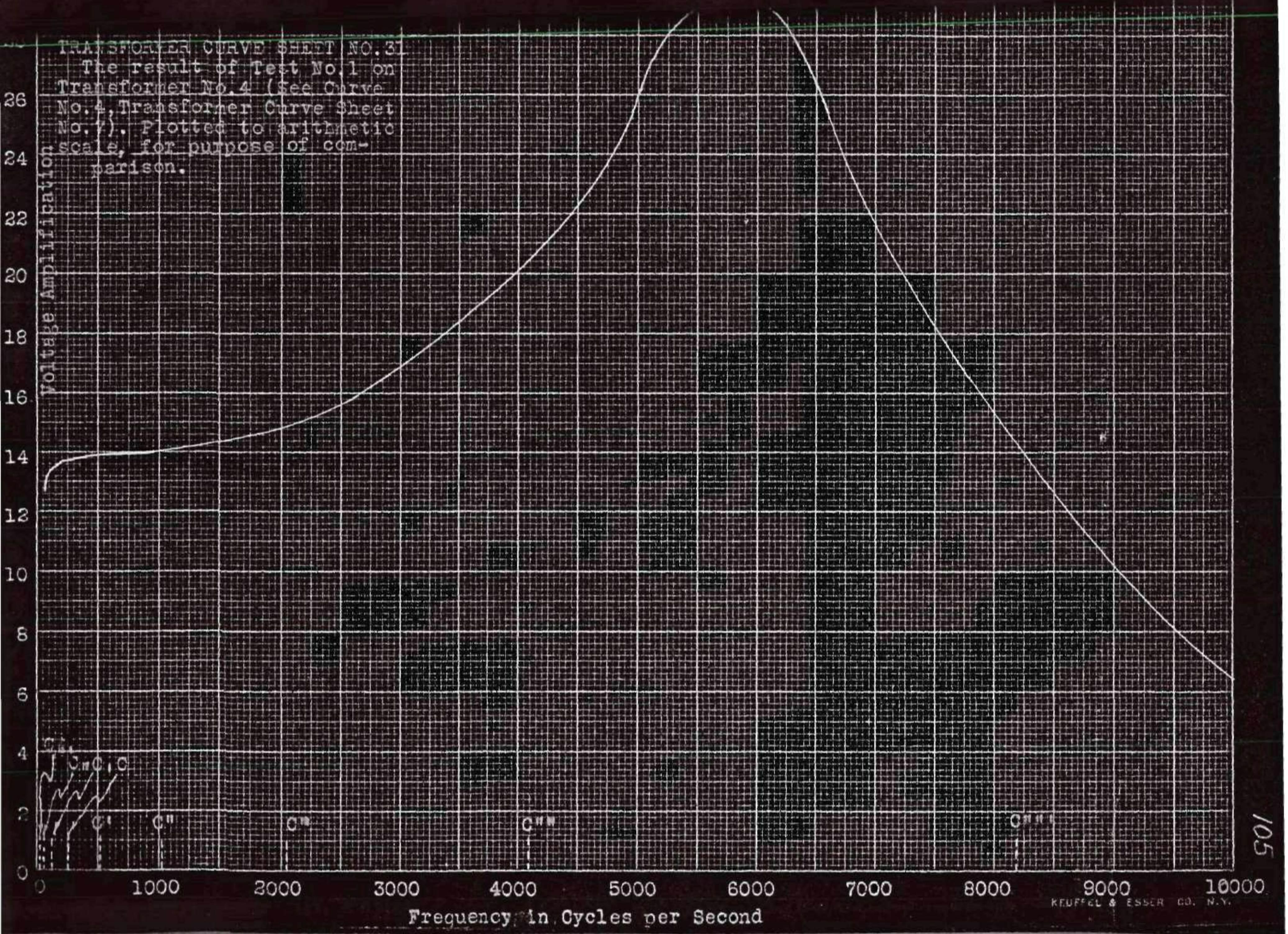

TRANSFORMER CURVE SHEET NO.27
Curves 1 and 2 show respectively the results Test No.1 on Transformers Nos.52 and 58. Curve 3 shows the results of Test No.1(a) on Transformer No. 58. (See Data Sheets Nos.60,79 and 80.)
42
36
30
24
18
12
6
0
60
100
200
300
500
1000
2000
3000
5000
10000
Frequency in Cycles per Second
1
2
3


TRANSFORMER CURVE SHEET NO.28
Curves 1 and 2 show respectively the results of Test No.1 on Transformers No.53 and 54.
Curves 3 and 4 show respectively the results of Test No.15 on Transformers Nos.54 and 53.
(See Data Sheets Nos.71,72,73 and 74 respectively.)
Voltage Amplification
42
36
30
24
18
12
6
0
1
2
3
4
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second
KEUFFEL & ESSER CO., N. Y. NO. N 358-43 R

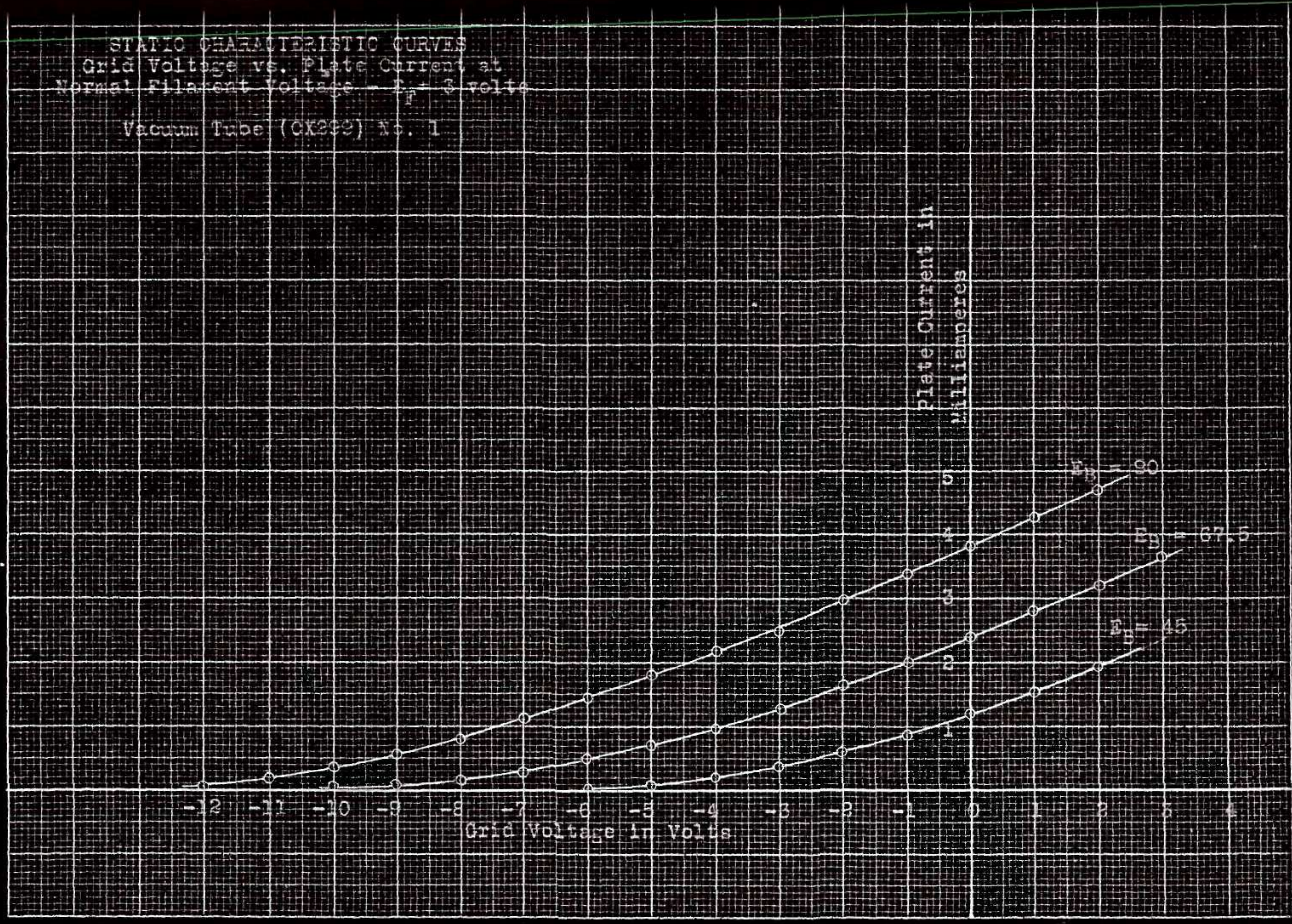

TRANSFORMER CURVE SHEET NO.29
Curve shows the results of
Test No.1 on Transformer No.43
(See Data Sheet No.47.)
48
42
36
30
24
18
12
6
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second

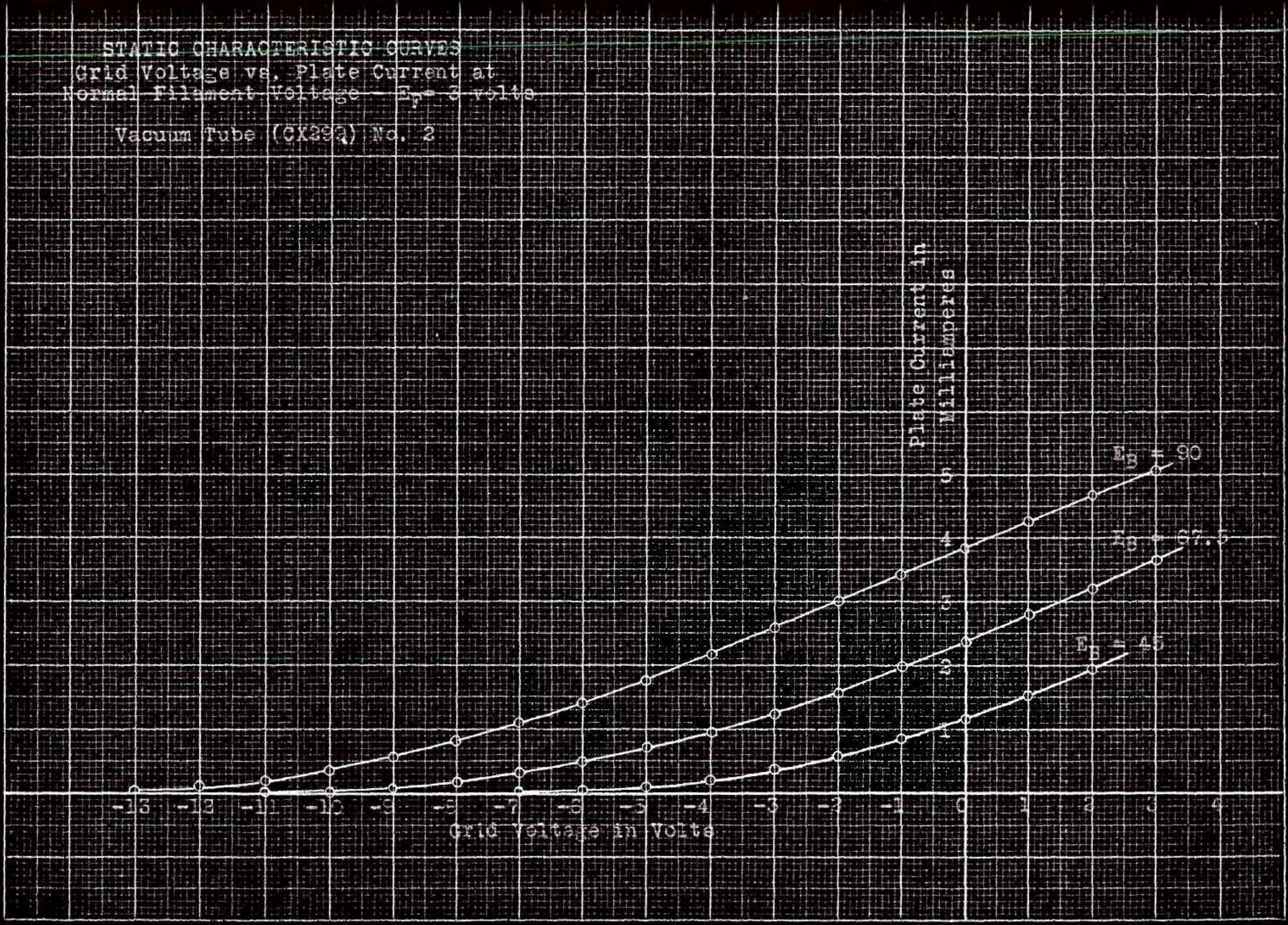

TRANSFORMER CURVE SHEET NO.30
Curve shows the results of
Test No.1 on Transformer No.58
(See Data Sheet No.81.)
42
36
30
24
18
12
6
0
60
100
200
300
500
700
1000
2000
3000
5000
10000
Frequency in Cycles per Second

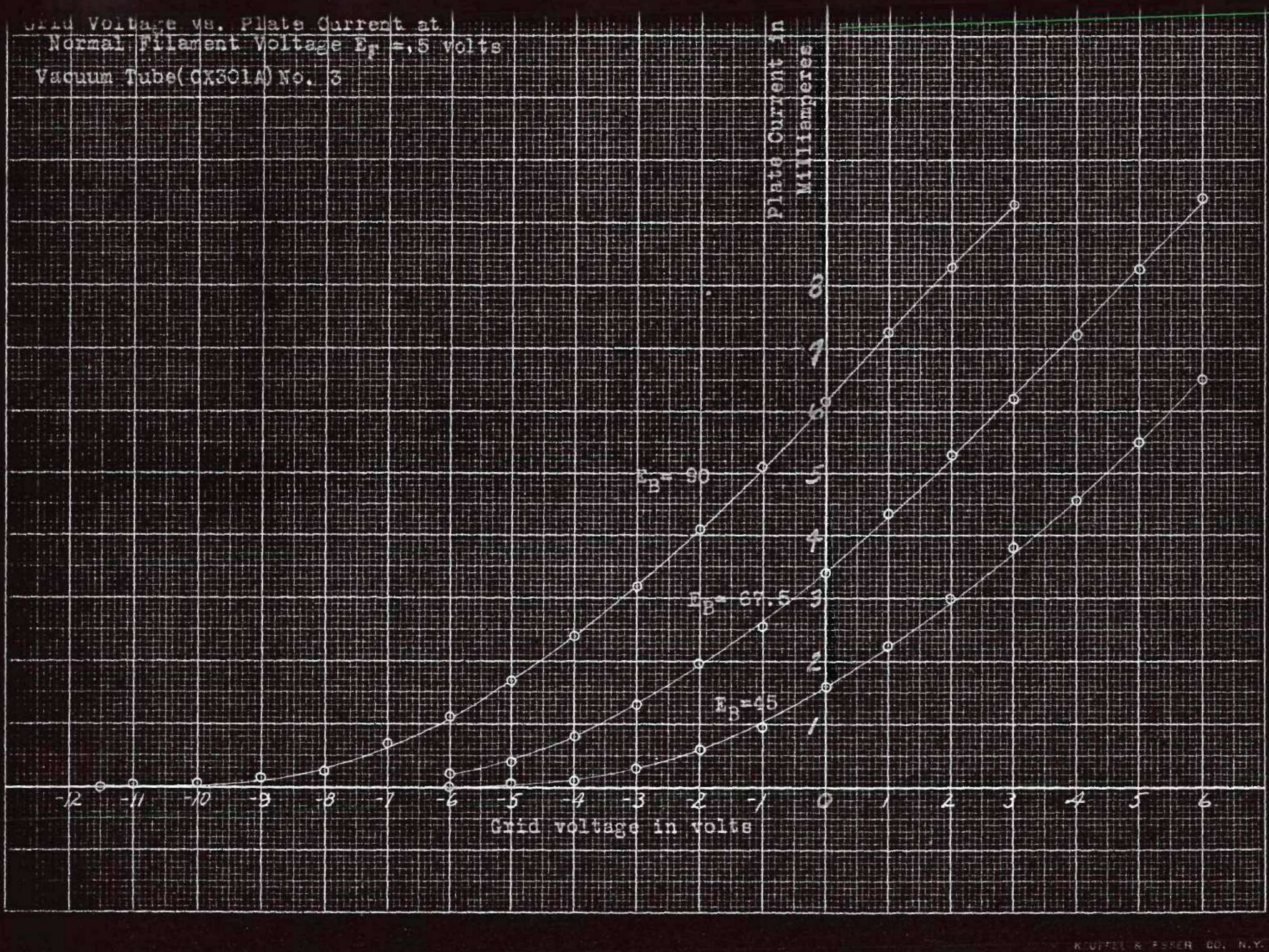
104



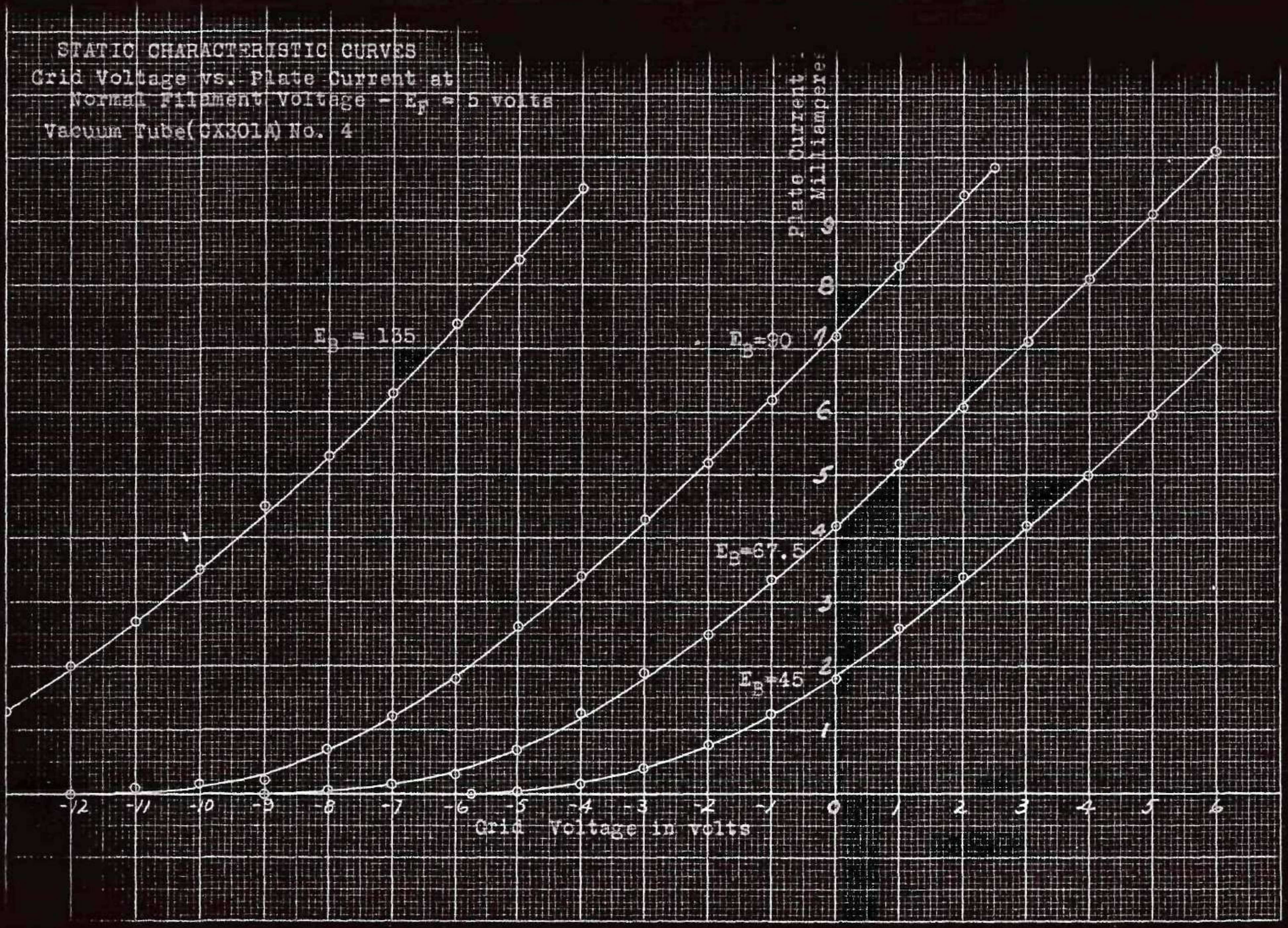
TRANSFORMER CURVE SHEET NO.31
The result of Test No.1 on Transformer No.4 (See Curve No.4,Transformer Curve Sheet No.7). Plotted to arithmetic scale, for purpose of comparison.
Voltage Amplification
Frequency in Cycles per Second
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
2
4
6
8
10
12
14
16
18
20
22
24
26
C'
C"
C'"
C""
C""'
KEUFFEL & ESSER CO. N.Y.

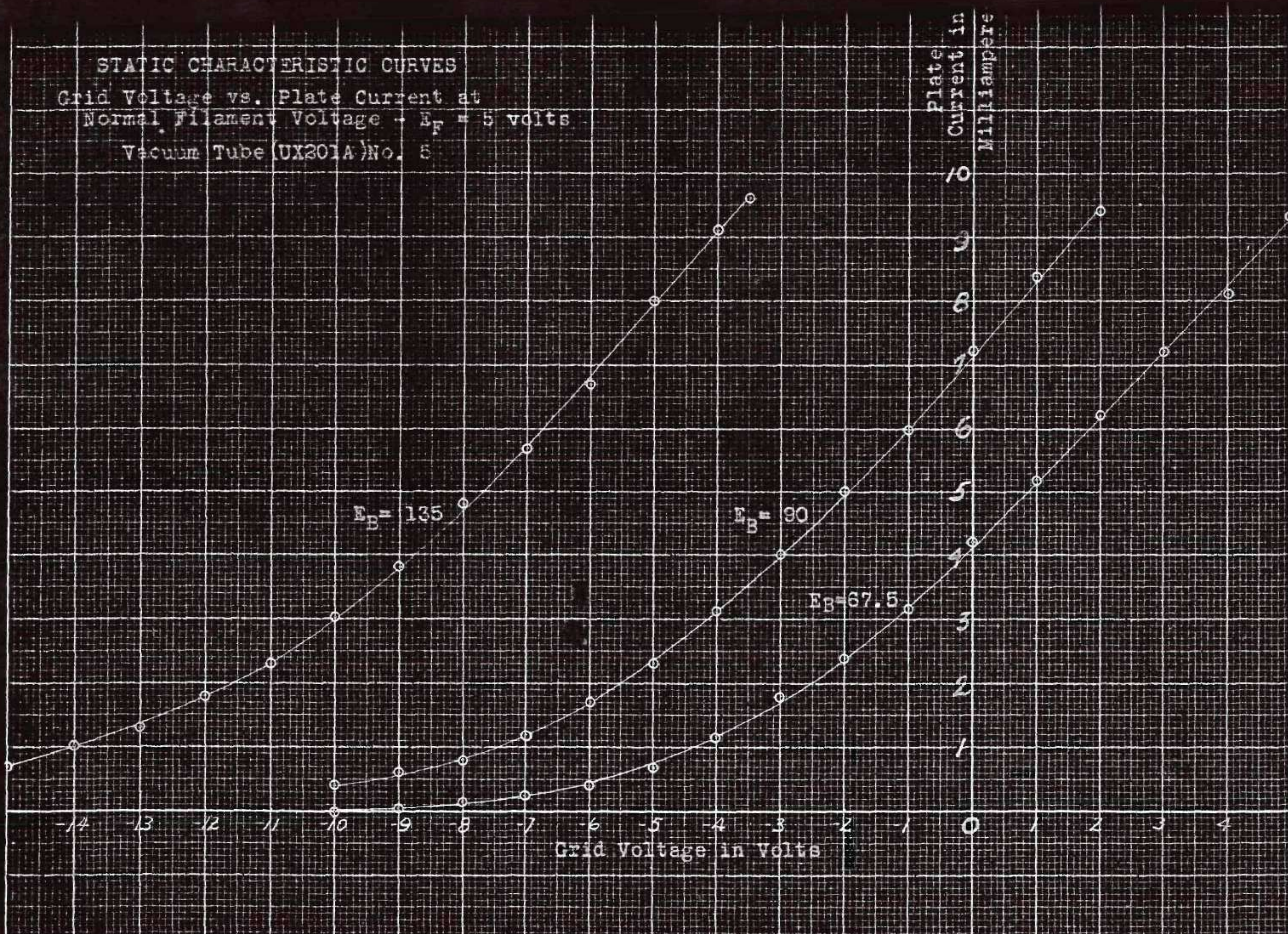

STATIC CHARACTERISTIC CURVES
Grid Voltage vs. Plate Current at
Normal Filament Voltage - E_F = 3 volts
Vacuum Tube (CX299) No. 1
Plate Current in Milliamperes
E_B = 90
E_B = 67.5
E_B = 45
1
2
3
4
5
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4
Grid Voltage in Volts


STATIC CHARACTERISTIC CURVES
Grid Voltage vs. Plate Current at
Normal Filament Voltage - E_F = 3 volts
Vacuum Tube (CX299) No. 2
Plate Current in
Milliamperes
E_B = 90
E_B = 67.5
E_B = 45
-13 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4
Grid Voltage in Volts

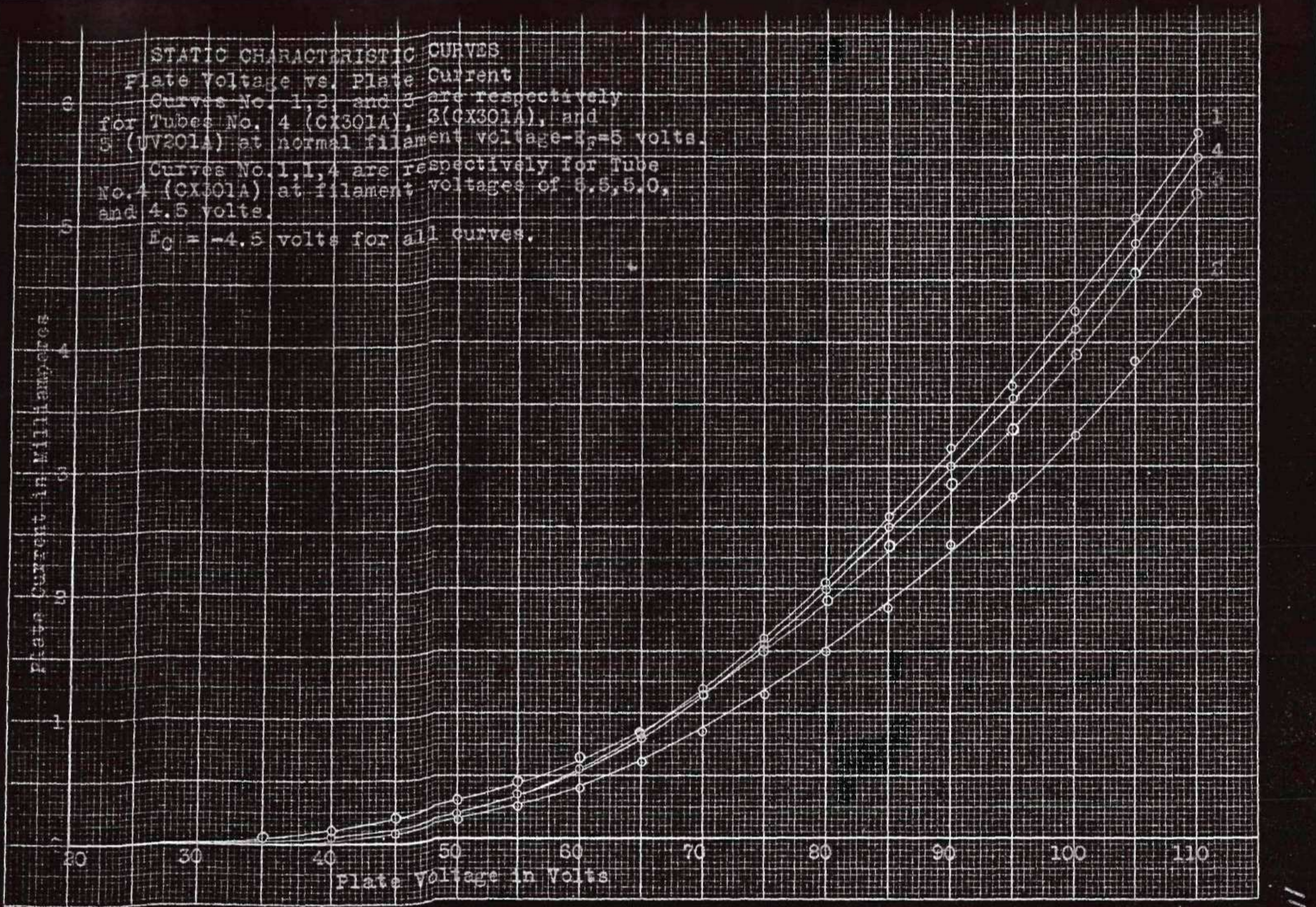


Grid Voltage vs. Plate Current at
Normal Filament Voltage Ef = 5 volts
Vacuum Tube (CX301A) No. 3
Plate Current in Milliamperes
1
2
3
4
5
6
7
8
EB = 90
EB = 67.5
EB = 45
-12
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
Grid voltage in volts
KEUFFEL & ESSER CO. N.Y.


STATIC CHARACTERISTIC CURVES
Grid Voltage vs. Plate Current at
Normal Filament Voltage - E_F = 5 volts
Vacuum Tube(CX301A) No. 4
Plate Current - Milliamperes
E_B = 135
E_B=90
E_B=67.5
E_B=45
1
2
3
4
5
6
7
8
9
-12
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
Grid Voltage in volts

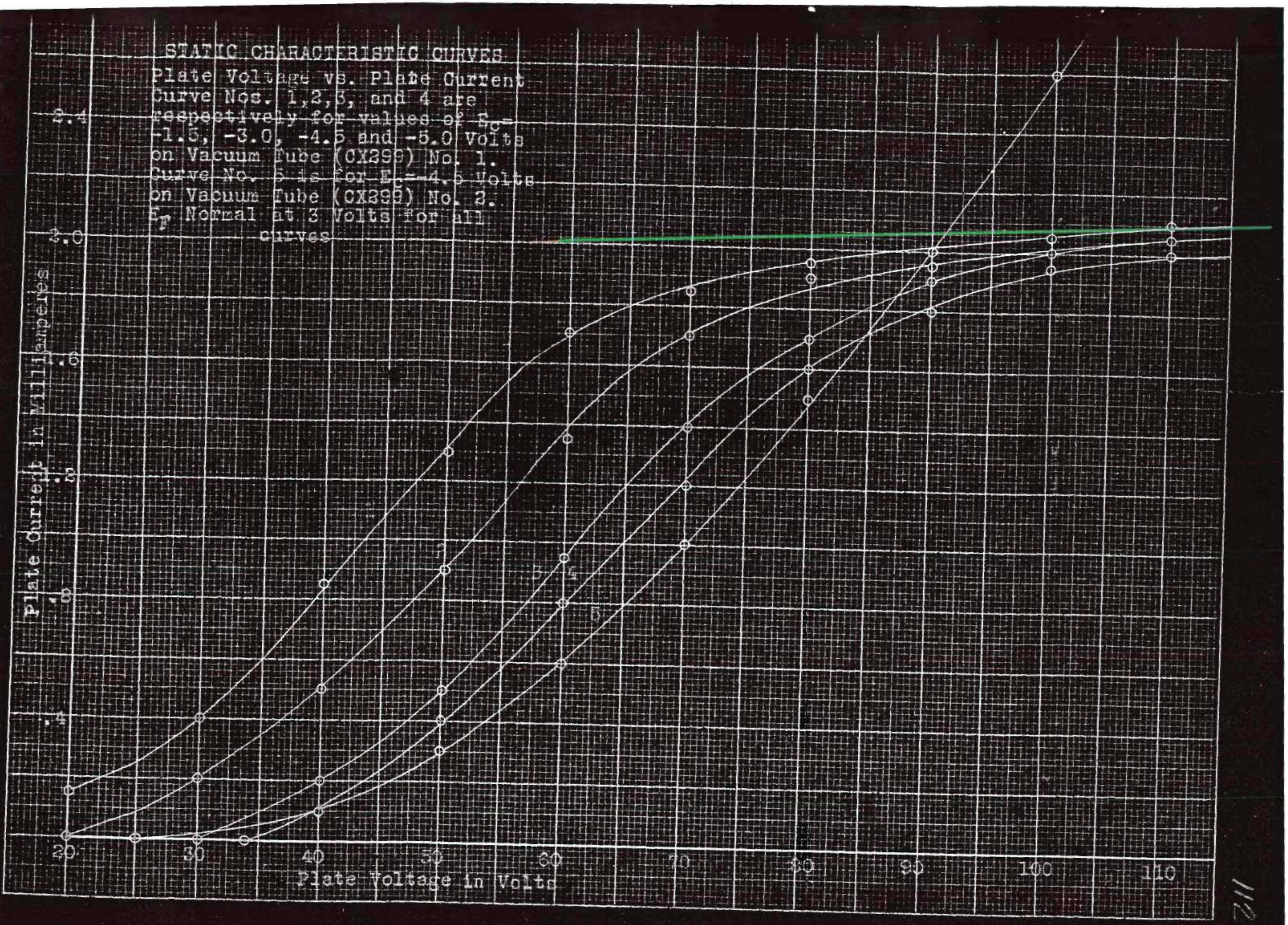


STATIC CHARACTERISTIC CURVES
Grid Voltage vs. Plate Current at
Normal Filament Voltage - E_F = 5 volts
Vacuum Tube (UX201A) No. 5
Plate Current in Milliampere
E_B= 135
E_B= 90
E_B=67.5
10
9
8
7
6
5
4
3
2
1
-14
-13
-12
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
1
2
3
4
Grid Voltage in Volts

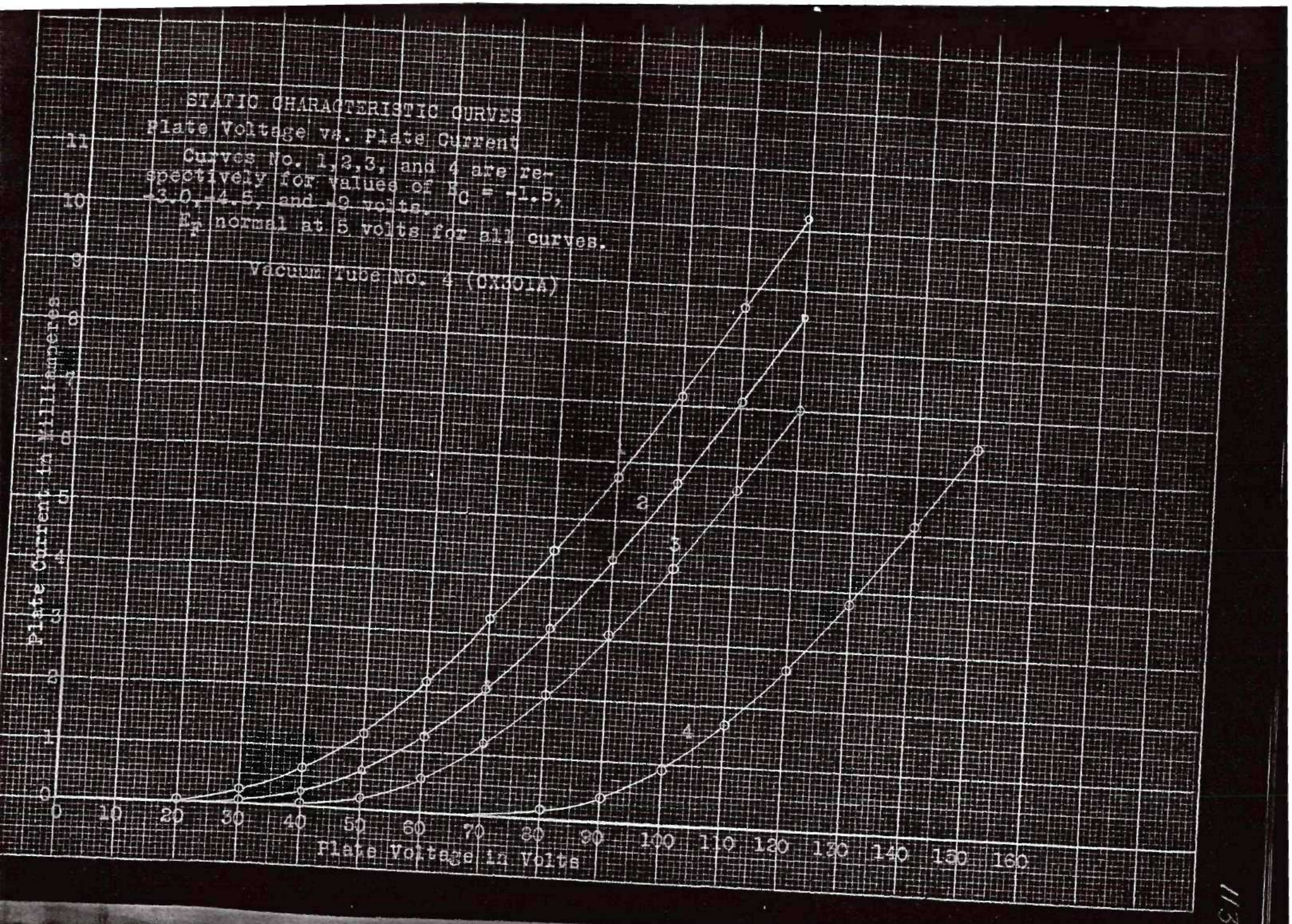


STATIC CHARACTERISTIC CURVES
Plate Voltage vs. Plate Current
Curves No. 1,2, and 3 are respectively for Tubes No. 4 (CX301A), 3(CX301A), and 5 (UV201A) at normal filament voltage-E_F=5 volts.
Curves No. 1,1,4 are respectively for Tube No. 4 (CX301A) at filament voltages of 5.5,5.0, and 4.5 volts.
E_C = -4.5 volts for all curves.
Plate Current in Milliamperes
Plate Voltage in Volts
20
30
40
50
60
70
80
90
100
110
1
2
3
4
5
6
1
4
3
2

111



STATIC CHARACTERISTIC CURVES
Plate Voltage vs. Plate Current
Curve Nos. 1,2,3, and 4 are
respectively for values of E_c=
-1.5, -3.0, -4.5 and -5.0 Volts
on Vacuum Tube (CX299) No. 1.
Curve No. 5 is for E_c=-4.5 Volts
on Vacuum Tube (CX299) No. 2.
E_F Normal at 3 Volts for all
curves
Plate Current in Milliamperes
2.4
2.0
1.6
.8
.4
Plate Voltage in Volts
20
30
40
50
60
70
80
90
100
110
3
4
5


STATIC CHARACTERISTIC CURVES
Plate Voltage vs. Plate Current
Curves No. 1,2,3, and 4 are respectively for values of E_C = -1.5, -3.0, -4.5, and -9 volts.
E_F normal at 5 volts for all curves.
Vacuum Tube No. 4 (CX301A)
Plate Current in Milliamperes
Plate Voltage in Volts
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
0 1 2 3 4 5 6 7 8 9 10 11
2
3
4
KEUFFEL & ESSER CO. N.Y.

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 1 Test No. 1 Sheet No. 1

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration X at 60 cycles			Reading for the amplifier at a given frequency f.						E2/E1	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a ⊙	f
k=1	k=25	k=1	k=.25	k=1	k=1	k=.25	k=1	k=1		
0a		.334a		.344	.5	20.0a	5.0a	9.95	19.9	60
.5		.344		"	"	33.4	8.6	13.5	27.0	100
.6		.348		"	"	2.3b	.58	17.95	35.9	200
2.0	2.0	.5		"	"	5.3	1.34	20.0	40.0	300
3.0	2.9	.73		"	"	6.4	1.6	20.5	41.0	400
4.0	4.2	1.05		"	"	7.0	1.75	20.75	41.5	500
5.0	6.0	1.5		"	"	7.0	1.75	20.75	41.5	700
6.0	8.3	2.07		"	"	8.9	2.22	21.6	43.2	1000
8.0	13.9	3.47		"	"	11.4	2.84	22.6	45.2	1500
10.0	20.7	5.09		"	"	15.4	3.85	23.95	47.9	2000
12.0	27.9	6.98		"	"	15.7	3.92	24.05	48.1	2200
14.0	36.9	9.22		"	"	15.0	3.75	24.0	48.0	2500
15.0	42.5	10.6		"	"	7.8	1.95	21.2	42.4	2700
15.0	.6	.15b		"	"	3.5	.88	18.9	37.8	3000
16.0	.9	.23		"	"	34.5a	8.64	13.55	27.1	3500
18.0	2.4	.6		"	"	26.0	6.5	11.5	23.0	4000
20.0	5.4	1.37		"	"	17.3	4.32	9.2	18.4	4500
25.0	19.0	4.75		"	"	12.0	3.0	7.4	14.8	5000
30.0	37.4	9.35		"	"	6.2	1.55	5.1	10.2	6000
				"	"	3.2	.8	3.4	6.8	7000
				"	"	2.2	.55	2.3	4.6	8000

REMARKS

⊙ See Transformer Curve Sheet No. 1.

X See Calibration Curve Sheet No. 1.

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 4 Test No. 1 Sheet No. 2

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C=4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration * at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output			$E2/E1$	
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	○ f
k=1	k=.25	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
0.0		.312a		.322	.5	2.0a	.5 a	2.2	4.4	60
.5		.322		"	"	3.0	.75	3.2	6.4	100
.6		.326		"	"	5.8	1.45	4.4	8.8	200
1.0		.355		"	"	7.9	1.97	5.95	11.9	300
2.0		.468		"	"	10.3	2.57	6.93	13.9	400
3.0	2.8a	.7		"	"	11.0	2.75	7.2	14.4	500
4.0	4.1	1.02		"	"	14.0	3.5	8.25	16.5	700
5.0	5.9	1.47		"	"	19.2	4.8	9.7	19.4	1000
6.0	8.1	2.02		"	"	21.7	5.42	10.3	20.6	1200
7.0	10.6	2.65		"	"	23.7	5.92	10.8	21.6	1500
8.0	13.4	3.35		"	"	24.0	6.0	10.88	21.8	2000
9.0	17.0	4.25		"	"	22.7	5.67	10.6	21.2	2200
10.0	20.1	5.02		"	"	21.3	5.42	10.3	20.6	2500
12.0	28.6	7.15		"	"	17.6	4.4	9.28	18.6	3000
14.0	37.2	9.3		"	"	15.0	3.75	8.56	17.2	3500
15.0	41.8	10.45		"	"	12.0	3.0	7.56	15.2	4000
15.0	.6b	.15b		"	"	9.9	2.47	6.78	13.6	4500
16.0	.9	.22		"	"	8.8	2.2	6.35	12.7	5000
18.0	2.5	.62		"	"	6.5	1.62	5.3	10.6	6000
[illegible]0.0	5.6	1.40		"	"	4.9	1.22	4.45	8.9	7000
[illegible]5.0	18.9	4.72		"	"	4.1	1.02	4.0	8.0	8000
[illegible]0.0	37.2	9.3		"	"	3.3	.82	3.45	6.9	9000
				"	"	3.0	.75	3.2	6.4	10000

REMARKS

* See Calibration Curve Sheet No. 2

○ See Transformer Curve Sheet No. 4

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 3 Test No. 1 Sheet No. 3

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C=4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.322a	.5	7.6a	1.9a	6.8	11.6	60
				"	"	12.0	3.0	7.55	15.1	100
				"	"	14.8	3.7	8.46	17.0	200
				"	"	16.0	4/0	8.85	17.7	300
				"	"	16.0	4.0	8.85	17.7	400
				"	"	16.9	4.22	9.1	18.2	500
				"	"	17.8	4.45	9.35	18.7	700
ee Sheet No. 2				"	"	17.9	4.47	9.4	18.8	1000
and				"	"	18.0	4.5	9.45	18.9	1500
alibration Curve				"	"	19.6	4.9	9.85	19.7	2000
Sheet No.2										
				"	"	21.6	5.4	10.25	20.5	2500
				"	"	23.0	5.75	10.68	21.4	3000
				"	"	25.5	6.38	11.22	22.5	3500
				"	"	30.9	7.72	12.55	23.1	4000
				"	"	36.4	9.1	13.8	27.6	4500
				"	"	40.4	10.1	14.8	29.6	5000
				"	"	1.6b	.4b	15.9	31.8	6000
				"	"	2.3	.57	16.3	32.6	7000
				"	"	37.6a	9.4a	14.1	28.2	8000
				"	"	22.2	5.55	10.5	21.0	9000
				"	"	13.0	3.25	6.38	12.8	10000

REMARKS

See Transformer Curve Sheet No. 3

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 2 Test No. 1 Sheet No. 4

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 , volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER										Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.								
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts			
E	I_p		I_p		E_1	I_p		E_2		E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1			
				.322	.5	16.5a	4.12a	9.0		18.0	60
				"	"	19.3	4.72	9.65		19.3	100
				"	"	21.5	5.4	10.35		20.7	200
				"	"	21.8	5.48	10.4		20.8	300
See Data Sheet No. 2 and Calibration Curve Sheet No. 2				"	"	21.8	5.48	10.4		20.8	400
				"	"	21.0	5.25	10.2		20.4	500
				"	"	20.8	5.2	10.15		20.3	700
				"	"	20.7	5.2	10.15		20.3	1000
				"	"	25.1	6.28	11.1		22.2	1500
				"	"	27.9	6.98	11.82		23.6	2000
				"	"	32.5	8.12	12.9		25.8	2500
				"	"	41.0	10.25	14.8		29.6	3000
				"	"	1.5b	.37b	17.0		34.0	3500
				"	"	4.6	1.15	19.5		39.0	4000
				"	"	3.2	.8	18.9		37.8	4500
				"	"	.5	.12	14.0		28.0	5000
				"	"	18.0a	4.5 a	9.42		18.8	6000
				"	"	8.7	2.17	6.25		12.5	7000
				"	"	5.0	1.25	4.55		9.1	8000
				"	"	3.3	.82	3.75		7.5	9000
				"	"	2.2	.55	2.3		4.6	10000

REMARKS

° See Transformer Curve Sheet No. 2.

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 5 Test No. 1 Sheet No. 5

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C=4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output			$E2/E1$	
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	° f
k=1	k=.25	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.322a	.5a	18.7a	4.67a	9.6	18.2	60
				"	"	30.4	7.6	12.4	24.8	100
				"	"	42.8	10.67	15.0	30.0	200
				"	"	0.5b	.12b	15.0	30.0	200
				"	"	0.8	.2	16.0	32.0	300
				"	"	1.1	.27	16.45	32.9	400
				"	"	1.4	.35	16.95	33.9	500
See Data Sheet				"	"	0.8	.2	16.0	32.0	700
No. 2 and				"	"	0.9	.22	16.1	32.2	1000
Calibration Curve				"	"	0.9	.22	16.1	32.2	1200
Sheet No. 2				"	"	1.3	.32	16.8	33.6	1500
				"	"	2.1	.52	17.7	35.4	2000
				"	"	3.3	.82	18.65	37.3	2200
				"	"	3.4	.85	18.75	37.5	2500
				"	"	3.9	.97	19.1	38.2	3000
				"	"	4.1	1.02	19.2	38.4	3500
				"	"	3.1	.77	18.55	37.1	4000
				"	"	1.7	.42	17.3	34.6	4500
				"	"	0.5	.12	15.0	30.0	5000
				"	"	24.5a	6.12a	11.0	22.0	6000
				"	"	13.5	3.37	8.05	16.1	7000
				"	"	7.9	1.96	5.9	11.8	8000
				"	"	4.1	1.02	4.0	8.0	9000
				"	"	3.4	.85	3.5	7.0	10000

REMARKS

° See Transformer Curve Sheet No. 3.

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **6** Test No. **1** Sheet No. **6**

Amplifier Tube

Type **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output			$E2/E1$	
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.322a	.5	4.3a	1.07a	4.1	8.2	60
				"	"	10.7	2.67	7.05	14.1	100
				"	"	22.2	5.55	10.5	21.0	200
				"	"	30.0	7.5	12.3	24.6	300
				"	"	32.8	8.2	13.0	26.0	400
				"	"	33.6	8.4	13.15	26.3	500
				"	"	38.7	9.67	14.35	28.7	700
				"	"	.3 b	.07b	14.5	29.0	1000
See Data Sheet										
No. 2 and				"	"	.4	.1	14.7	29.4	1500
Calibration Curve				"	"	.7	.17	15.6	31.2	2000
Sheet No. 2										
				"	"	1.0	.25	16.3	32.6	2500
				"	"	1.2	.4	17.15	34.3	3000
				"	"	1.8	.45	17.4	34.8	3500
				"	"	2.0	.5	17.6	35.2	4000
				"	"	2.0	.5	17.6	35.2	4500
				"	"	1.4	.35	16.95	33.9	5000
				"	"	.9	.22	16.1	32.2	6000
				"	"	35.8 a	8.95a	13.7	27.4	7000
				"	"	23.9	5.97	10.9	21.8	8000
				"	"	15.7	3.92	8.75	17.5	9000
				"	"	11.0	2.75	7.15	14.3	10000

REMARKS

See Transformer Curve Sheet No. 6

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 7 Test No. 1 Sheet No. 7

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	° f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.322a	.5	5.5a	1.37a	4.8	9.6	60
				"	"	11.9	2.97	7.5	15.0	100
				"	"	20.8	5.2	10.15	20.3	200
				"	"	26.9	6.72	11.6	23.2	300
				"	"	28.7	7.2	12.0	24.0	400
				"	"	31.0	7.75	12.55	25.1	500
				"	"	33.0	8.25	13.0	26.0	700
				"	"	33.2	8.4	13.15	26.3	1000
				"	"	33.3	8.4	13.15	26.3	1200
				"	"	35.0	8.75	13.5	27.0	1500
				"	"	35.8	8.95	13.7	27.4	2000
				"	"	33.0	8.25	13.0	26.0	2500
See Data Sheet				"	"	33.5	8.37	13.1	26.2	3000
No. 2 and				"	"	33.2	8.4	13.15	26.3	3500
Calibration				"	"	32.0	8.0	12.8	25.6	4000
Curve Sheet				"	"	32.2	8.05	12.8	25.6	4500
No. 2				"	"	31.5	7.87	12.65	25.3	5000
				"	"	30.4	7.6	12.4	24.9	6000
				"	"	28.0	7.0	11.85	23.7	7000
				"	"	25.0	6.25	11.1	22.2	8000
				"	"	22.0	5.5	10.4	20.8	9000
				"	"	17.8	4.45	9.45	18.9	10000

REMARKS

° See Transformer Curve Sheet No. 7

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 8 Test No. 1 Sheet No. 8

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output			E2/E1	
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.322a	.5	1.3a	.33a	.9	1.8	60
				"	"	2.0	.5	2.2	4.4	100
				"	"	4.7	1.89	5.8	11.6	200
				"	"	10.4	2.6	6.9	13.8	300
				"	"	12.0	3.0	7.9	15.8	400
				"	"	14.7	3.66	8.4	16.8	500
				"	"	20.3	5.08	10.0	20.0	700
See Data Sheet				"	"	27.0	6.74	11.6	23.2	1000
No. 2 and				"	"	29.8	7.45	12.3	24.6	1200
Calibration Curve				"	"	31.0	7.73	12.5	25.0	1500
Sheet No. 2				"	"	32.0	8.0	12.8	25.6	2000
				"	"	33.8	8.43	13.2	26.4	2500
				"	"	33.0	8.24	13.0	26.0	3000
				"	"	31.0	7.73	12.5	25.0	3500
				"	"	27.3	6.81	11.7	23.4	4000
				"	"	26.7	6.68	11.5	23.0	4500
				"	"	24.6	6.15	11.0	22.0	5000
				"	"	22.3	5.57	10.5	21.0	6000
				"	"	18.1	4.52	9.5	19.0	7000
				"	"	14.7	3.67	8.4	16.8	8000
				"	"	11.9	2.97	7.5	15.0	9000
				"	"	10.1	2.52	6.8	13.6	10000

REMARKS

See Transformer Curve Sheet No. 8

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 9 Test No. 1 Sheet No. 9

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C=4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER										Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output					
			milliamperes		equiv. volts	milliamperes		equiv. volts			
E	I_p		I_p		E_1	I_p		E_2		E_a o	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1			
				.322a	.5	4.7a	1.18a	4.4		8.8	60
				"	"	9.3	2.32	6.5		13.0	100
				"	"	17.2	4.3	9.2		18.4	200
				"	"	21.3	5.03	10.0		20.0	300
				"	"	23.1	5.77	10.7		21.4	400
				"	"	24.8	6.22	11.1		22.2	500
				"	"	26.7	6.7	11.55		23.1	700
				"	"	27.2	6.82	11.7		23.4	1000
				"	"	28.5	7.13	11.95		23.9	1200
				"	"	29.5	7.4	12.2		24.4	1500
				"	"	29.0	7.27	12.1		24.2	2000
See Data Sheet				"	"	30.3	7.59	12.4		24.8	2200
No. 2				"	"	31.0	7.77	12.55		25.1	2500
and				"	"	32.2	8.1	12.9		25.8	3000
Calibration				"	"	33.5	8.4	13.2		26.4	3500
Curve				"	"	35.8	8.95	13.7		27.4	4000
Sheet No. 2				"	"	35.7	8.94	13.7		27.4	4500
				"	"	35.4	8.88	13.6		27.2	5000
				"	"	35.8	8.95	13.7		27.4	6000
				"	"	34.0	8.5	13.25		26.5	7000
				"	"	28.0	7.0	11.85		23.7	8000
				"	"	22.0	5.5	10.45		20.9	9000
				"	"	16.1	4.02	8.85		17.7	10000

REMARKS

o See Transformer Curve Sheet No. 9

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **10** Test No. **1** Sheet No. **10**

Amplifier Tube

Type **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER										Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							$E2/E1$	
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts			
E	I_p		I_p		E_1	I_p		E_2		E_a	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1			
				.322a	.5	5.3a	1.32a	4.7		9.4	60
				"	"	10.7	2.67	7.0		14.0	100
				"	"	22.4	5.6	10.5		21.0	200
				"	"	27.6	6.9	11.75		23.5	300
				"	"	30.1	7.51	12.3		24.6	400
				"	"	33.3	8.32	13.1		26.2	500
				"	"	36.0	9.0	13.7		27.4	700
				"	"	35.5	8.88	13.7		27.4	1000
				"	"	35.3	8.83	13.55		27.1	1200
				"	"	36.2	9.05	13.75		27.5	1500
				"	"	35.0	8.75	13.5		27.0	2000
				"	"	33.7	8.42	13.1		26.2	2200
				"	"	31.7	7.92	12.7		25.4	2500
				"	"	29.3	7.32	12.15		24.3	3000
				"	"	27.2	6.8	11.65		23.3	3500
				"	"	25.0	6.25	11.15		22.3	4000
				"	"	22.8	5.7	10.6		21.2	4500
				"	"	21.0	5.25	10.2		20.4	5000
				"	"	16.1	4.02	8.85		17.7	6000
				"	"	12.0	3.00	7.5		15.0	7000
				"	"	9.3	2.32	6.5		13.0	8000
				"	"	7.0	1.75	5.5		11.0	9000
				"	"	5.0	1.25	4.5		9.0	10000

REMARKS

See Transformer Curve Sheet No.10

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 11   Test No. 1   Sheet No. 11

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C=4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration * at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a o	f
k=1	k=.25	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
0.0		.332a		.341	.5	8.0a	2.0a	6.0	12.0	60
.5		.341		"	"	12.8	3.2	7.8	15.6	100
.6		.345		"	"	24.7	6.17	11.2	22.4	200
1.0		.370		"	"	29.0	7.25	12.25	24.5	300
2.0	2.0a	.500		"	"	32.8	8.2	13.1	26.2	400
3.0	3.0	.750		"	"	34.4	8.6	13.45	26.9	500
4.0	4.1	1.025		"	"	33.1	8.27	13.2	26.4	700
5.0	6.0	1.50		"	"	28.6	7.15	12.15	24.3	1000
6.0	8.1	2.025		"	"	27.5	6.87	11.9	23.8	1200
7.0	10.6	2.45		"	"	23.6	5.9	10.95	21.9	1500
8.0	13.5	3.375		"	"	18.4	4.6	9.5	19.0	2000
9.0	16.8	4.200		"	"					
10.0	20.2	5.05		"	"	13.9	3.48	8.2	16.4	2500
12.0	28.5	7.125		"	"	10.4	2.6	6.95	13.9	3000
14.0	37.0	9.25		"	"	8.7	2.17	6.3	12.6	3500
15.0	41.6	10.400		"	"	7.4	1.85	5.75	11.5	4000
15.0	.25b	.042b		"	"	6.0	1.5	5.0	10.0	4500
16.0	.70	.175		"	"	4.8	1.2	4.3	8.6	5000
18.0	2.0	.50		"	"	3.5	.87	3.4	6.8	6000
20.0	4.8	1.20		"	"	2.9	.75	3.0	6.0	7000
25.0	16.6	4.15		"	b"	2.2	.55	2.3	4.6	8000
30.0	34.0	8.50		"	"	2.0	.5	2.0	4.0	9000
35.0M	53.0	13.25		"	"	1.8	.45	1.75	3.5	10000
16.0	46.6a	11.65a								

REMARKS

* See Calibration Curve Sheet No. 3

° See Transformer Curve Sheet No. 11

† At this voltage and the C battery used the grid circuit of the Vacuum Tube Voltmeter drew 50 microamperes. 3500 ohms was the grid series resistance at this reading.

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 12 Test No. 1 Sheet No. 12

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B=90 volts; E_C=4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts	$E2 / E1$	
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=.25	k=1	k=.25	k=1	k=1	k=.25	k=1	k=1		
				.341a	.5	7.1 a	1.77a	5.6	11.2	60
				"	"	8.8	2.2	6.3	12.6	100
				"	"	11.5	2.87	7.3	14.6	200
				"	"	12.4	3.1	7.65	15.3	300
				"	"	12.7	3.17	7.75	15.5	400
				"	"	12.85	3.21	7.8	15.6	500
				"	"	12.9	3.22	7.8	15.6	700
ee Data Sheet No.11				"	"	12.8	3.2	7.8	15.6	1000
and				"	"	12.6	3.15	7.75	15.5	1200
alibration Curve				"	"	11.6	2.9	7.35	14.7	1500
Sheet No. 3				"	"	11.1	2.78	7.2	14.4	2000
				"	"	11.2	2.8	7.2	14.4	2200
				"	"	11.0	2.75	7.15	14.3	2500
				"	"	9.3	2.42	6.7	13.4	3000
				"	"	8.5	2.12	6.2	12.4	3500
				"	"	7.8	1.95	5.9	11.8	4000
				"	"	7.8	1.95	5.9	11.8	4500
				"	"	7.3	1.82	5.7	11.4	5000
				"	"	6.3	1.57	5.15	10.3	6000
				"	"	5.9	1.48	5.00	10.0	7000
				"	"	5.0	1.25	4.45	8.9	8000
				"	"	4.3	1.07	4.00	8.0	9000
				"	"	4.2	1.05	3.95	7.9	10000

REMARKS

° See Transformer Curve Sheet No. 11

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 13 Test No. 1 Sheet No. 13

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output			E2/E1	
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a c	f
k=1	k=	k=1	k=	k=1	k=1	k=	k=1	k=1		
				.341 a	.5	5.7 a	1.67a	5.35	10.7	60
				"	"	8.15	2.04	6.1	12.2	100
				"	"	18.5	4.62	9.55	19.1	200
				"	"	31.3	7.82	12.8	25.6	300
				"	"	41.5	10.37	14.95	29.9	400
				"	"	44.5	11.12	15.55	31.1	500
See Data Sheet				"	"	1.0 b	.25b	16.85	33.7	700
No. 11				"	"	2.3	.57	18.25	36.5	1000
and				"	"	2.4	.6	18.4	36.8	1200
Calibration Curve				"	"	2.3	.57	18.25	36.5	1500
Sheet No. 3				"	"	1.7	.42	17.75	35.5	2000
				"	"	1.6	.4	17.6	35.2	2200
				"	"	.8	.2	16.55	33.1	2500
				"	"	44.5	a11.12a	15.55	31.1	3000
				"	"	41.0	10.25	14.85	29.7	3500
				"	"	33.9	8.37	13.3	26.6	4000
				"	"	30.5	7.62	12.6	25.2	4500
				"	"	25.3	6.32	11.35	22.7	5000
				"	"	20.2	5.05	10.00	20.0	6000
				"	"	17.1	4.27	9.1	18.2	7000
				"	"	13.7	3.42	8.1	16.2	8000
				"	"	10.6	2.65	6.9	13.8	9000
				"	"	9.4	2.35	6.6	13.2	10000

REMARKS

c See Transformer Curve Sheet No. 7

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **14** Test No. **1** Sheet No. **14**

Amplifier Tube

Type **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output			E2/E1	
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.341a	.5	8.5 a	2.13	6.2	12.4	60
				"	"	14.5	3.62	8.35	16.7	100
				"	"	24.0	4.0	8.8	17.6	200
				"	"	30.2	7.55	12.55	25.1	300
				"	"	32.0	8.0	12.95	25.9	400
				"	"	34.9	8.72	13.55	27.1	500
				"	"	35.5	8.87	13.69	27.4	700
				"	"	38.2	9.55	14.25	28.5	1000
				"	"	39.0	9.75	14.45	28.9	1200
				"	"	41.8	10.45	15.00	30.0	1500
				"	"	45.8	11.45	15.8	31.6	2000
				"	"	.6b	.15	16.2	32.4	2200
See Data Sheet				"	"	.7	.18	16.3	32.6	2500
No. 11 and				"	"	1.3	.43	17.3	34.6	3000
Calibration Curve				"	"	1.8	.42	17.7	35.4	3500
Sheet No. 3				"	"	2.1	.52	18.1	36.2	4000
				"	"	2.3	.57	18.3	36.6	4500
				"	"	2.2	.55	18.2	36.4	5000
				"	"	42.5 a	10.62	15.15	30.3	6000
				"	"	24.8	6.2	11.25	22.5	7000
				"	"	15.3	3.82	8.6	17.2	8000
				"	"	10.0	2.5	6.8	13.6	9000
				"	"	6.0	1.5	5.0	10.0	10000

REMARKS

° See Transformer Curve Sheet No. 14

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **15** Test No. **1** Sheet No. **15**

Amplifier Tube

Type **CX301A** No.**4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.341a	.5	2.6a	.65a	3.6	7.2	60
				"	"	5.8	1.45	4.95	9.9	100
				"	"	12.0	3.0	7.55	15.1	200
				"	"	17.3	4.32	9.2	18.4	300
				"	"	22.9	5.72	10.75	21.5	400
				"	"	25.0	6.25	11.3	22.6	500
				"	"	28.8	7.0	12.0	24.0	700
				"	"	33.0	8.25	13.15	26.3	1000
See Data Sheet				"	"	32.8	8.2	13.1	26.2	1200
No. 11				"	"	33.1	8.3	13.2	26.4	1500
and				"	"	33.8	8.45	13.35	26.7	2000
Calibration				"	"	33.1	8.28	13.2	26.4	2200
Curve Sheet				"	"	30.2	7.55	12.55	25.1	2500
No.3				"	"	30.0	7.5	12.5	25.0	3000
				"	"	28.4	7.1	12.1	24.2	3500
				"	"	27.8	6.92	11.9	23.8	4000
				"	"	26.0	6.5	11.55	23.1	4500
				"	"	22.3	5.58	10.55	21.1	5000
				"	"	18.8	4.7	9.65	19.3	6000
				"	"	14.9	3.72	8.5	17.0	7000
				"	"	11.0	2.75	7.15	14.3	8000
				"	"	8.0	2.0	6.0	12.0	9000
				"	"	6.0	1.5	5.0	10.0	10000

REMARKS

° See Transformer Curve No. 12

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 16 Test No. 1 Sheet No. 16

■ Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.341a	.5	9.8 a	2.45a	6.75	13.5	60
				"	"	16.2	4.05	8.85	17.7	100
				"	"	33.2	8.3	13.2	26.4	200
				"	"	41.0	10.25	14.85	29.9	300
				"	"	45.1	11.27	15.65	31.3	400
				"	"	46.0	11.5	15.9	31.8	500
				"	"	.6 b	.15	16.2	32.4	700
				"	"	1.1	.37	17.4	34.8	1000
				"	"	1.0	.25	16.9	33.8	1200
See Data Sheet				"	"	1.4	.35	17.4	34.8	1500
No. 11				"	"	1.9	.47	17.9	35.8	2000
and				"	"	2.2	.55	18.2	36.4	2200
Calibration				"	"	2.5	.62	18.5	37.0	2500
Curve Sheet				"	"	2.8	.7	18.8	37.6	3000
No. 3				"	"	2.8	.7	18.8	37.6	3500
				"	"	1.8	.45	17.8	35.6	4000
				"	"	.8	.2	16.4	32.8	4500
				"	"	43.2 a	10.8	15.3	30.6	5000
				"	"	28.2	7.05	12.05	24.1	6000
				"	"	16.2	4.05	8.85	17.7	7000
				"	"	9.8	2.45	6.7	13.4	8000
				"	"	5.8	1.45	4.9	9.8	9000
				"	"	3.9	.97	3.7	7.4	10000

REMARKS

° See Transformer Curve Sheet No. 13

VOLTAGE AMPLIFICATION TEST DATA SHEET

ansformer No. 17 Test No. 1 Sheet No. 17

Amplifier Tube

pe CX301A No. 4 Voltages:-- E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER										Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							$E2/E1$	
ut ts	Plate current in milliamperes		Input			Output					
			milliamperes		equiv. volts	milliamperes		equiv. volts			
	I_p		I_p		E_1	I_p		E_2		E_a o	f
=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1			
				.341 a	.5	1.8a	.45a	1.8		3.6	60
				"	"	2.6 a	.65	2.65		5.3	100
				"	"	6.2	1.55	5.1		10.2	200
				"	"	10.5	2.62	6.95		13.9	300
				"	"	14.1	3.52	8.25		16.5	400
				"	"	16.1	4.05	8.9		17.8	500
				"	"	18.8	4.7	9.6		19.2	700
				"	"	23.4	5.85	10.95		21.9	1000
				"	"	24.5	6.12	11.15		22.3	1200
				"	"	25.0	6.25	11.3		22.6	1500
				"	"	27.3	6.82	11.85		23.7	2000
				"	"	27.8	6.95	11.95		23.9	2200
				"	"	29.8	7.45	12.45		24.9	2500
				"	"	31.2	7.8	12.75		25.5	3000
e Data Sheet				"	"	31.5	7.87	12.8		25.6	3500
No. 11				"	"	31.9	7.98	12.9		25.8	4000
and				"	"	35.9	8.97	13.8		27.6	4500
libration Curve				"	"	39.8	9.95	14.6		29.2	5000
Sheet No. 3				"	"	42.2	10.55	15.1		30.2	6000
				"	"	42.3	10.57	15.1		30.2	7000
				"	"	34.9	8.72	13.55		27.1	8000
				"	"	25.6	6.4	11.4		22.8	9000
				"	"	17.2	4.3	9.15		18.3	10000

REMARKS

o See Transformer Curve Sheet No. 1

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 18 Test No. 1 Sheet No. 18

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.341 a	.5	2.6 a	.65a	2.7	5.4	60
				"	"	4.8	1.2	4.3	8.6	100
				"	"	10.7	2.67	7.05	14.1	200
				"	"	13.8	3.45	8.15	16.3	300
				"	"	16.5	4.12	8.95	17.9	400
				"	"	18.9	4.72	9.7	19.4	500
				"	"	19.0	4.75	9.7	19.4	700
				"	"	21.5	5.37	10.35	20.7	1000
				"	"	21.5	5.37	10.35	20.7	1200
				"	"	22.8	5.7	10.7	21.4	1500
				"	"	23.2	5.8	10.8	21.6	2000
				"	"	24.3	6.07	11.1	22.2	2200
				"	"	25.5	6.37	11.4	22.8	2500
See Data Sheet				"	"	26.9	6.72	11.75	23.5	3000
No. 11 and				"	"	28.8	7.2	12.2	24.4	3500
Calibration				"	"	30.4	7.6	12.6	25.2	4000
Curve				"	"	31.5	7.87	12.85	25.7	4500
Sheet				"	"	32.3	8.07	13.0	26.0	5000
No. 3				"	"	30.5	7.62	12.6	25.2	6000
				"	"	26.2	6.55	11.6	23.2	7000
				"	"	18.2	4.55	11.45	22.9	8000
				"	"	11.9	3.97	8.8	17.6	9000
				"	"	9.0	2.25	6.4	12.8	10000

REMARKS

° See Transformer Curve Sheet No. 2

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **19** Test No. **1** Sheet No. **19**

Amplifier Tube

Type **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output			E2/E1	
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.341 a	.5	7.5a	1.87a	5.8	11.6	60
				"	"	14.0	3.5	8.0	16.0	100
				"	"	24.0	6.0	11.0	22.0	200
				"	"	29.9	7.48	12.5	25.0	300
				"	"	33.5	8.39	13.4	26.8	400
				"	"	34.0	8.5	13.45	26.9	500
				"	"	36.0	9.0	13.7	27.4	700
				"	"	39.9	9.98	14.65	29.3	1000
				"	"	39.9	9.98	14.65	29.3	1200
				"	"	42.5	10.62	15.1	30.2	1500
				"	"	44.9	11.22	15.6	31.2	2000
See Data Sheet				"	"	45.2	11.3	15.7	31.4	2200
No. 11				"	"	.5b	.12b	16.1	32.2	2500
and				"	"	1.0	.25	16.9	33.8	3000
Calibration				"	"	1.1	.27	16.95	33.9	3500
Curve Sheet				"	"	1.1	.27	16.95	33.9	4000
No. 3				"	"	.9	.22	16.8	32.6	4500
				"	"	41.0a	10.3	14.9	29.8	5000
				"	"	23.9	5.97	10.95	21.9	6000
				"	"	12.1	3.02	7.5	15.0	7000
				"	"	7.0	1.75	5.5	11.0	8000
				"	"	4.5	1.12	4.1	8.2	9000
				"	"	3.0	.75	3.0	6.0	10000

REMARKS

° See Transformer Curve Sheet No. 15

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 20 Test No. 1 Sheet No. 20

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	° f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.341	.5	1.9a	.47	a 1.85	3.7	60
				"	"	2.6	.65	2.7	5.4	100
				"	"	5.7	1.42	4.9	9.8	200
				"	"	8.4	2.10	6.15	12.3	300
				"	"	10.9	2.70	7.1	14.2	400
				"	"	12.0	3.00	7.5	15.0	500
				"	"	13.0	3.25	7.85	15.7	700
				"	"	14.9	3.70	8.45	16.9	1000
				"	"	15.0	3.75	8.5	17.0	1200
See Data Sheet				"	"	16.0	4.00	8.8	17.6	1500
No. 11 and				"	"	16.8	4.20	8.95	17.9	2000
Calibration				"	"	16.5	4.10	8.9	17.8	2200
Curve Sheet				"	"	16.5	4.10	8.9	17.8	2500
No. 3				"	"	17.1	4.30	9.15	18.3	3000
				"	"	18.4	4.60	9.5	19.0	3500
				"	"	19.0	4.75	9.7	19.4	4000
				"	"	18.5	4.60	9.5	19.0	4500
				"	"	19.5	4.85	9.8	19.6	5000
				"	"	20.1	5.02	10.0	20.0	6000
				"	"	19.9	4.97	9.95	19.9	7000
				"	"	17.2	4.30	9.15	18.3	8000
				"	"	15.9	3.97	8.75	17.5	9000
				"	"	13.0	3.25	7.85	15.7	10000

REMARKS

° See Transformer Curve Sheet No. 15

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **21** Test No. **1** Sheet No. **21**

Amplifier Tube

Type **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER											Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.								$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output						
			milliamperes		equiv. volts	milliamperes		equiv. volts				
E	I_p		I_p		E_1	I_p		E_2			E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1				
				.341a	.5	1.5 a	.37a	1.1			2.2	60
				"	"	1.8	.45	1.8			3.6	100
				"	"	2.0	.5	2.1			4.2	200
				"	"	2.3	.57	2.3			4.6	300
				"	"	2.4	.6	2.5			5.0	400
				"	"	2.5	.62	2.6			5.2	500
				"	"	2.5	.62	2.6			5.2	700
				"	"	2.5	.62	2.6			5.2	1000
				"	"	2.55	.64	2.65			5.3	1500
				"	"	2.7	.67	2.75			5.5	2000
See Data Sheet				"	"	2.7	.67	2.75			5.5	2500
No. 11				"	"	2.8	.7	2.85			5.7	3000
and				"	"	2.9	.72	2.9			5.8	3500
Calibration				"	"	2.85	.71	2.85			5.7	4000
Curve Sheet				"	"	2.8	.70	2.85			5.7	4500
No. 3				"	"	2.8	.7	2.85			5.7	5000
				"	"	2.9	.72	2.9			5.8	6000
				"	"	3.0	.75	3.0			6.0	7000
				"	"	3.0	.75	3.0			6.0	8000
				"	"	3.4	.85	3.35			6.7	9000
				"	"	3.8	.95	3.65			7.3	10000

REMARKS

° See Transformer Curve Sheet No. 1

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 22 Test No. 1 Sheet No. 22

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.341a	.5	9.5a	2.37a	6.6	13.2	60
				"	"	15.8a	3.95	8.75	17.5	100
				"	"	31.9	7.97	12.9	25.8	200
				"	"	39.5	9.87	14.55	29.1	300
				"	"	41.7	10.42	15.0	30.0	400
				"	"	45.3	11.32	15.7	31.4	500
				"	"	.6b	.15b	16.25	32.5	700
				"	"	.7	.17	16.3	32.6	1000
				"	"	.8	.2	16.6	33.2	1200
See Data Sheet				"	"	.6	.15	16.25	32.5	1500
No. 11				"	"	.6	.15	16.25	32.5	2000
and				"	"	46.7a	11.67	16.0	32.0	2200
Calibration				"	"	47.0	11.75	16.0	32.0	2500
Curve Sheet				"	"	45.3	11.32	15.7	31.4	3000
No. 3				"	"	40.8	10.2	14.8	29.6	3500
				"	"	35.8	8.95	13.75	27.5	4000
				"	"	32.5	8.12	13.05	26.1	4500
				"	"	30.0	7.5	12.5	25.0	5000
				"	"	22.3	5.57	10.6	21.2	6000
				"	"	17.2	4.3	9.2	18.4	7000
				"	"	12.7	3.17	7.75	15.5	8000
				"	"	9.7	2.42	6.8	13.6	9000
				"	"	7.4	1.85	5.75	11.5	10000

REMARKS

° See Transformer Curve Sheet No. 16

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 23 Test No. 1 Sheet No. 23

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration * at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
			Input			Output				
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	° f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
0.0	.	.316a								
.5		.325		.325a	.5	1.8a	.45a	1.8	3.6	60
.6		.329		"	"	2.5	.62	2.6	5.2	100
1.0		.354		"	"	4.7	1.17	4.25	8.5	200
2.0	2.0 a	.5		"	"	7.2	1.8	5.65	11.3	300
3.0	3.0	.75		"	"	9.1	2.27	6.45	12.9	400
4.0	4.1	1.02		"	"	10.8	2.7	7.1	14.2	500
5.0	6.0	1.5		"	"	11.7	2.92	7.4	14.8	700
6.0	8.1	2.02		"	"	14.0	3.5	8.2	16.4	1000
7.0	10.6	2.45		"	"	14.3	3.57	8.25	16.5	1200
8.0	13.5	3.375		"	"	14.4	3.6	8.3	16.6	1500
9.0	16.8	4.2		"	"	15.0	3.75	8.5	17.0	2000
10.0	20.2	5.05								
12.0	28.5	7.125		"	"	15.4	3.85	8.6	17.2	2500
14.0	37.0	9.25		"	"	16.0	4.0	8.8	17.6	3000
15.0	41.6	10.5		"	"	16.2	4.05	8.85	17.7	3500
16.0	46.6	11.65		"	"	17.0	4.25	9.1	18.2	4000
15.0	.2b	.05b		"	"	16.7	4.17	9.0	18.0	4500
16.0	.4	.1		"	"	17.8	4.45	9.35	18.7	5000
18.0	1.2	.3		"	"	18.8	4.7	9.65	19.3	6000
20.0	3.5	.87		"	"	20.7	5.17	10.15	20.3	7000
25.0	14.7	3.62		"	"	22.0	5.5	10.5	21.0	8000
30.0	31.5	7.87		"	"	24.0	6.0	11.0	22.0	9000
				"	"	26.2	6.55	11.55	23.1	10000

REMARKS

* See Calibration Curve Sheet No. 4

° See Transformer Curve Sheet No. 17

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 24 Test No. 1 Sheet No. 24

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	2.1a	.52a	2.2	4.4	60
				"	"	3.2	.8	3.2	6.4	100
				"	"	6.6	1.65	5.3	10.6	200
				"	"	8.3	2.07	6.1	12.2	300
				"	"	9.6	2.4	6.65	13.3	400
				"	"	10.8	2.7	7.10	14.2	500
				"	"	12.0	3.0	7.5	15.0	700
				"	"	12.8	3.2	7.8	15.6	1000
See Data Sheet No. 23										
and				"	"	13.1	3.27	7.9	15.8	1500
Calibration				"	"	14.3	3.57	8.3	16.6	2000
Curve										
Sheet				"	"	14.8	3.7	8.45	16.9	2500
No. 4				"	"	14.8	3.7	8.45	16.9	3000
				"	"	15.3	3.82	8.6	17.2	3500
				"	"	15.8	3.95	8.75	17.5	4000
				"	"	16.4	4.1	8.9	17.8	4500
				"	"	16.6	4.15	9.0	18.0	5000
				"	"	18.3	4.57	9.45	18.9	6000
				"	"	19.0	4.75	9.7	19.4	7000
				"	"	19.3	4.82	9.8	19.6	8000
				"	"	20.6	5.15	10.15	20.3	9000
				"	"	21.8	5.45	10.45	20.9	10000

REMARKS

° See Transformer Curve Sheet No. 17

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 25 Test No. 1 Sheet No. 25

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						E2/E1	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	3.2a	.8 a	3.2	6.4	60
				"	"	6.5	1.62	5.25	10.5	100
				"	"	17.8	4.45	9.35	18.7	200
				"	"	24.0	6.0	11.0	22.0	300
				"	"	31.6	7.9	12.85	25.7	400
				"	"	36.7	9.17	13.9	27.8	500
				"	"	40.0	10.0	14.65	29.3	700
See Data Sheet				"	"	41.8	10.45	15.05	30.1	1000
No. 23 and				"	"	45.3	11.32	15.75	31.5	1200
Calibration				"	"	.7b	.17b	16.85	33.7	1500
Curve				"	"	.7	.17	16.85	33.7	2000
Sheet				"	"	.6	.15	16.8	33.6	2200
No. 4				"	"	.6	.15	16.8	33.6	2500
				"	"	.5	.12	16.4	32.8	3000
				"	"	45.0a	11.25a	15.65	31.3	3500
				"	"	42.4	10.6	15.1	30.2	4000
				"	"	38.7	9.67	14.35	28.7	4500
				"	"	36.6	9.15	13.9	27.8	5000
				"	"	27.3	6.82	11.85	23.7	6000
				"	"	22.7	5.67	10.7	21.4	7000
				"	"	15.2	3.80	8.85	17.7	8000
				"	"	11.3	3.57	8.25	16.5	9000
				"	"	8.8	2.2	6.3	12.6	10000

REMARKS

° See Transformer Curve Sheet No. 17

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **26** Test No. **1** Sheet No. **26**

Amplifier Tube

Type **CX301a** No. **4** Voltages:— E_B=**90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output			E2/E1	
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	° f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	2.2 a	.55a	2.3	4.6	60
				"	"	5.8	1.45	4.95	9.9	100
				"	"	17.0	4.25	9.1	18.2	200
				"	"	31.8	7.95	12.8	25.6	300
				"	"	42.5	10.62	15.2	30.4	400
				"	"	1.0b	.25b	17.65	35.3	500
				"	"	2.3	.57	19.1	38.2	700
See Data Sheet				"	"	1.0	.25	17.65	35.3	1000
No. 23 and				"	"	.5	.12	16.5	31.0	1200
Calibration				"	"	36.3a	9.07a	13.85	27.7	1500
Curve				"	"	25.0	6.25	11.2	22.4	2000
Sheet				"	"	20.7	5.17	10.1	20.2	2200
No. 4				"	"	15.6	3.9	8.2	16.4	2500
				"	"	11.8	2.95	7.45	14.9	3000
				"	"	8.7	2.17	6.25	12.5	3500
				"	"	6.6	1.65	5.3	10.6	4000
				"	"	5.1	1.27	4.5	9.0	4500
				"	"	4.0	1.0	3.9	7.8	5000
				"	"	2.8	.7	2.9	5.8	6000
				"	"	2.2	.55	2.3	4.6	7000
				"	"	1.7	.45	1.8	3.6	8000
				"	"	1.7	.45	1.8	3.6	9000
				"	"	1.4	.35	1.0	2.0	10000

REMARKS

° See Transformer Curve Sheet No. 18

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 27   Test No. 1   Sheet No. 27

Amplifier Tube

Type CX301A   No. 4   Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output			$E2/E1$	
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	° f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325	.5	2.	.5	2.0	4.0	60
				"	"	3.3	.82	3.35	6.7	100
				"	"	7.0	1.75	5.5	11.0	200
				"	"	9.4	2.35	6.55	13.1	300
				"	"	11.0	2.75	7.15	14.3	400
				"	"	12.6	3.15	7.75	15.5	500
				"	"	13.5	3.37	8.05	16.1	700
				"	"	13.8	3.45	8.15	16.3	1000
				"	"	14.2	3.55	8.25	16.5	1200
				"	"	13.45	3.36	8.05	16.1	1500
				"	"	13.7	3.42	8.1	16.2	2000
				"	"	13.6	3.40	8.05	16.1	2200
See Data Sheet				"	"	13.3	3.32	7.95	15.9	2500
No. 23				"	"	13.0	3.25	7.85	15.7	3000
and				"	"	12.8	3.2	7.8	15.6	3500
Calibration				"	"	12.3	3.07	7.6	15.2	4000
Curve				"	"	11.9	2.97	7.45	14.9	4500
Sheet No. 4				"	"	11.4	2.85	7.4	14.8	5000
				"	"	10.7	2.67	6.9	13.8	6000
				"	"	9.7	2.42	6.7	13.4	7000
				"	"	8.8	2.2	6.3	12.6	8000
				"	"	8.0	2.0	5.95	11.9	9000
				"	"	6.7	1.67	5.35	10.7	10000

REMARKS

° See Transformer Curve No. 19

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 28 Test No. 1 Sheet No. 28

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B=90 volts; E_C=4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER										Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.								
Input volts	Plate current in milliamperes		Input			Output					
			milliamperes		equiv. volts	milliamperes		equiv. volts			
E	I_p		I_p		E_1	I_p		E_2		E_a	° f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1			
						2.0 a	.5 a	2.0		4.0	60
				.325	.5	4.2 a	1.	3.85		7.7	100
				"	"	14.7	3.67	8.4		16.8	200
				"	"	27.8	6.95	11.85		23.7	300
				"	"	42.6	10.65	15.2		30.4	400
				"	"	.7 b	.17 b	16.95		33.9	500
				"	"	3.1	.77	19.75		39.5	700
				"	"	1.0	.25	17.65		35.3	1000
				"	"	45.4 a	11.35 a	15.8		31.6	1200
				"	"	34.2	8.55	13.35		26.7	1500
				"	"	21.4	5.35	10.3		20.6	2000
See	Data Sheet			"	"	17.7	4.42	9.3		18.6	2200
	No. 23			"	"	13.7	3.42	7.8		15.6	2500
and				"	"	9.3	2.32	6.5		13.0	3000
Calibration				"	"	7.0	1.75	5.5		11.0	3500
	Curve			"	"	5.5	1.37	4.75		9.5	4000
	Sheet No.4			"	"	4.4	1.1	4.1		8.2	4500
				"	"	3.9	.97	3.75		7.5	5000
				"	"	3.0	.75	3.1		6.2	6000
				"	"	2.3	.57	2.35		4.7	7000
				"	"	2.0	.5	2.0		4.0	8000
				"	"	1.9	.47	1.9		3.8	9000
				"	"	1.7	.42	1.6		3.2	10000

REMARKS

° See Transformer Curve Sheet No. 18

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 1 Sheet No. 29

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C=4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER										Voltage amplification E2/E1	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.								
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts			
E	I_p		I_p		E_1	I_p		E_2		E_a	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1			
				.325a	.5	17.8 a	4.45a	9.35		18.7	60
				"	"	20.6	5.15	10.1		20.2	100
				"	"	21.0	5.25	10.2		20.4	200
				"	"	22.7	5.67	10.55		21.1	300
				"	"	23.2	5.80	10.75		21.5	400
				"	"	23.8	5.95	10.9		21.8	500
				m"	"	23.7	5.92	10.9		21.8	700
				"	"	23.3	5.82	10.8		21.6	1000
See Data Sheet				"	"	23.0	5.75	10.75		21.5	1500
No. 23				"	"	23.3	5.82	10.8		21.6	2000
and						23.3	5.82	10.8		21.6	2200
Calibration				"	"	23.0	5.75	10.75		21.5	2500
Curve				"	"	24.1	6.02	11.0		22.0	3000
Sheet No.4				"	"	27.9	6.97	11.85		23.7	3500
				"	"	28.5	7.12	12.0		24.0	4000
				"	"	31.9	7.97	12.8		25.6	4500
				"	"	30.0	7.5	12.4		24.8	5000
				"	"	24.6	6.15	11.1		22.2	6000
				"	"	22.7	5.67	10.65		21.3	7000
				"	"	15.0	3.75	8.5		17.0	8000
				"	"	8.7	2.17	6.25		12.5	9000
				"	"	5.0	1.25	4.5		9.0	10000

REMARKS

° See Transformer Curve Sheet No. 20,21,22,23

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 30 Test No. 1 Sheet No. 30

Amplifier Tube

Type CX301A No. Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output				
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	° f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	14.5 a	3.62a	8.35	16.7	60
				"	"	14.7	3.67	8.4	16.8	100
				"	"	15.6	3.9	8.7	17.4	200
				"	"	16.0	4.0	8.85	17.7	300
				"	"	16.4	4.1	8.95	17.9	400
				"	"	16.7	4.17	9.0	18.0	500
				"	"	17.3	4.32	9.2	18.4	700
				"	"	17.1	4.27	9.1	18.2	1000
				"	"	18.5	4.62	9.5	19.0	1200
See Data Sheet				"	"	18.9	4.72	9.65	19.7	1500
No. 23				"	"	19.7	4.92	9.85	19.9	2000
and				"	"	20.7	5.17	10.1	20.2	2200
Calibration				"	"	21.7	5.42	10.4	20.8	2500
Curve				"	"	22.7	5.67	10.6	21.2	3000
Sheet				"	"	25.5	6.37	11.3	22.6	3500
No. 4				"	"	25.6	6.4	11.35	22.7	4000
				"	"	27.3	6.82	11.75	23.5	4500
				"	"	25.1	6.27	11.2	22.4	5000
				"	"	23.0	5.75	10.7	21.4	6000
				"	"	18.3	4.57	9.45	18.9	7000
				"	"	9.9	2.47	6.7	13.4	8000
				"	"	5.4	1.35	4.7	9.4	9000
				"	"	3.6	.9	3.55	7.1	10000

REMARKS

° See Transformer Curve Sheet No. 20

VOLTAGE AMPLIFICATION TEST DATA SHEET

ransformer No. **29** Test No. **1** Sheet No. **31**

Amplifier Tube

ype **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts.

VACUUM TUBE VOLTMETER									Voltage amplification E_2/E_1	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output				
nput olts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k= .25	k=1	k=1		
				.325a	.5	18.4a	4.60a	9.5	19.0	60
				"	"	21.2	5.30	10.25	20.5	100
				"	"	21.7	5.43	10.40	20.8	200
				"	"	22.5	5.63	10.60	21.2	300
				"	"	22.4	5.60	10.55	21.1	400
				"	"	22.9	5.75	10.70	21.4	500
				"	"	22.4	5.60	10.55	21.1	700
				"	"	22.8	5.70	10.65	21.3	1000
				"	"	23.2	5.80	10.75	21.5	1200
				"	"	23.7	5.93	10.90	21.8	1500
				"	"	24.8	6.20	11.15	22.3	2000
				"	"	25.6	6.40	11.35	22.7	2200
				"	"	26.0	6.50	11.45	22.9	2500
				"	"	26.6	6.65	11.60	23.2	3000
				"	"	28.8	7.20	12.10	24.2	3500
See Data Sheet				"	"	30.3	7.58	12.45	24.9	4000
No. 23				"	"	32.0	8.00	12.85	25.7	4500
and				"	"	31.0	7.75	12.60	25.2	5000
Calibration				"	"	24.4	6.10	11.05	22.1	6000
Curve				"	"	23.6	5.90	10.85	21.7	7000
Sheet No. 4				"	"	15.0	3.75	8.50	17.0	8000
				"	"	9.7	2.43	6.70	13.4	9000
				"	"	6.0	1.50	5.0	10.0	10000

REMARKS

°See Transformer Curve Sheet No. 20 and 21,22,23

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29   Test No. 2   Sheet No. 32

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 3 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output			$E2/E1$	
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	19.2a	4.8 a	9.7	18.4	60
				"	"	22.7	5.67	10.65	21.3	100
				"	"	25.0	6.25	11.2	22.4	200
				"	"	25.0	6.25	11.2	22.4	300
				"	"	25.7	6.42	11.4	22.8	400
				"	"	26.7	6.67	11.6	23.2	500
				"	"	26.3	6.57	11.5	23.0	700
				"	"	26.5	6.62	11.55	23.1	1000
See Data Sheet				"	"	25.4	6.35	11.3	22.6	1200
No. 23				"	"	25.7	6.42	11.4	22.8	1500
and				"	"	25.7	6.42	11.4	22.8	2000
Calibration				"	"	26.9	6.72	11.65	23.3	2200
Curve				"	"	29.2	7.3	12.2	24.4	2500
Sheet No.4				"	"	30.2	7.55	12.45	24.9	3000
				"	"	32.0	8.0	12.85	25.7	3500
				"	"	33.1	8.37	13.2	26.4	4000
				"	"	35.5	8.87	13.65	27.3	4500
				"	"	35.7	8.92	13.7	27.4	5000
				"	"	27.8	6.45	11.4	22.8	6000
				"	"	24.8	6.2	11.05	22.1	7000
				"	"	16.0	4.0	8.8	17.6	8000
				"	"	9.2	2.3	6.45	12.9	9000
				"	"	6.3	1.57	5.2	10.4	10000

REMARKS

° See Transformer Curve Sheet No. 21

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 3 Sheet No. 33

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 67.5 volts; E_C= 3 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						E_2/E_1	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	° f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	18.5 a	4.62a	9.55	19.1	60
				"	"	20.4	5.1	10.05	20.1	100
				"	"	21.8	5.45	10.4	20.8	200
				"	"	22.1	5.52	10.5	21.0	300
				"	"	22.9	5.72	10.7	21.4	400
				"	"	21.9	5.47	10.45	20.9	500
See Data Sheet				"	"	22.4	5.6	10.6	21.2	700
No. 23				"	"	21.5	5.37	10.35	20.7	1000
and										
Calibration				"	"	21.9	5.47	10.45	20.9	1500
Curve				"	"	22.5	5.62	10.6	21.2	2000
Sheet No. 4										
				"	"	23.4	5.85	10.85	21.7	2500
				"	"	22.9	5.72	10.7	21.4	3000
				"	"	24.0	6.0	11.0	22.0	3500
				"	"	25.0	6.25	11.2	22.4	4000
				"	"	25.5	6.37	11.35	22.7	4500
				"	"	22.1	5.52	10.5	21.0	5000
				"	"	18.0	4.5	9.4	18.8	6000
				"	"	15.1	3.77	8.5	17.0	7000
				"	"	10.2	2.8	6.85	13.7	8000
				"	"	7.2	1.8	5.6	11.2	9000
				"	"	4.9	1.22	4.45	8.9	10000

REMARKS

° See Transformer Curve Sheet No. 21

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 4 Sheet No. 34

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B=67.5 volts; E_C= 1.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output			$E2/E1$	
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	° f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	19.0a	4.75a	9.7	19.4	60
				"	"	20.8	5.2	10.15	20.3	100
				"	"	21.0	5.25	10.2	20.4	200
				"	"	21.1	5.27	10.2	20.4	300
				"	"	21.0	5.25	10.2	20.4	400
				"	"	21.0	5.25	10.2	20.4	500
				"	"	21.0	5.25	10.2	20.4	700
				"	"	21.8	5.45	10.4	20.8	1000
				"						
				"	"	22.0	5.5	10.5	21.0	1500
				"	"	23.8	5.95	10.95	21.9	2000
See Data Sheet				"	"	24.0	6.0	11.0	22.0	2200
No. 23				"	"	26.0	6.5	11.45	22.9	2500
and				"	"	27.5	6.87	11.8	23.6	3000
Calibration				"	"	28.9	7.22	12.15	24.3	3500
Curve Sheet				"	"	31.0	7.75	12.65	25.3	4000
No. 4				"	"	32.0	8.0	12.85	25.7	4500
				"	"	30.9	7.72	12.6	25.2	5000
				"	"	24.2	6.05	11.05	22.1	6000
				"	"	22.0	5.5	10.5	21.0	7000
				"	"	15.4	3.85	8.65	17.7	8000
				"	"	9.5	2.37	6.6	13.2	9000
				"	"	5.0	1.22	4.3	8.6	10000

REMARKS

° See Transformer Curve Sheet No. 21

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 31 Test No. 1 Sheet No. 35

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C=-4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER*									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output			$E2/E1$	
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	3.5a	0.87a	3.45	6.9	60
				"	"	5.5	1.37	4.7	9.4	100
				"	"	9.0	2.25	6.35	12.7	200
				"	"	10.5	2.62	7.0	14.0	300
				"	"	11.5	2.87	7.3	14.6	400
				"	"	11.9	2.97	7.45	14.9	500
				"	"	13.0	3.25	7.85	15.7	700
				"	"	13.0	3.25	7.85	15.7	1000
See Data Sheet				"	"	13.2	3.4	8.1	16.2	1500
No. 23				"	"	14.1	3.52	8.25	16.5	2000
and										
Calibration				"	"	15.0	3.75	8.5	17.0	2500
Curve				"	"	16.2	4.05	8.9	17.8	3000
Sheet				"	"	17.2	4.3	9.2	18.4	3500
No. 4				"	"	19.4	4.85	9.8	19.6	4000
				"	"	22.0	5.5	10.45	20.9	4500
				"	"	23.8	5.95	10.95	21.9	5000
				"	"	32.0	8.0	12.9	25.8	6000
				"	"	41.0	10.25	14.85	29.7	7000
				"	"	41.0	10.25	14.85	29.7	8000
				"	"	42.2	10.55	15.1	30.2	7500
				"	"	32.5	8.12	12.95	25.9	9000
				"	"	21.0	5.25	10.2	20.4	10000

REMARKS

° See Transformer Curve Sheet No. 1

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 32 Test No. 1 Sheet No. 36

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						E2/E1	
			Input			Output				
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	° f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	5.5a	1.3a	4.6	9.2	60
				"	"	11.0	2.75	7.15	14.3	100
				"	"	20.0	5.0	9.95	19.9	200
				"	"	24.5	6.12	11.1	22.2	300
				"	"	27.9	6.97	11.85	23.7	400
				"	"	30.0	7.5	12.4	24.8	500
				"	"	31.5	7.87	12.75	25.5	700
				"	"	33.0	8.25	13.1	26.2	1000
See Data Sheet				"	"	33.5	8.37	13.2	26.4	1200
No. 23				"	"	36.5	9.12	13.9	27.8	1500
and				"	"	38.5	9.62	14.35	28.7	2000
Calibration				"	"	40.9	10.22	14.85	29.7	2200
Curve				"	"	40.2	10.05	14.7	29.4	2500
Sheet				"	"	45.0	11.25	15.75	31.5	3000
No. 4				"	"	.5b	.12b	16.7	33.4	3500
				"	"	.9	.22	17.6	35.2	4000
				"	"	.5	.12	16.7	33.4	4500
				"	"	39.9a	9.97a	14.65	29.3	5000
				"	"	22.1	5.52	10.5	21.0	6000
				"	"	12.1	3.02	7.6	15.2	7000
				"	"	6.9	1.72	5.5	11.0	8000
				"	"	4.0	1.0	3.9	7.8	9000
				"	"	3.0	.75	3.1	6.2	10000

REMARKS

° See Transformer Curve Sheet No. 15

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 33 Test No. 1 Sheet No. 37

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output			$E2/E1$	
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=25	k=1	k=1		
				.325a	.5	15.0	3.75a	8.5	17.0	60
				"	"	18.2	4.55	9.45	18.9	100
				"	"	22.4	5.6	10.6	21.2	200
				"	"	23.1	5.77	10.75	21.5	300
				"	"	23.3	5.82	10.8	21.6	400
				"	"	24.2	6.05	11.0	22.0	500
				"	"	25.3	6.32	11.3	22.6	700
				"	"	26.1	6.52	11.5	23.0	1000
See Data Sheet				"	"	27.0	6.75	11.7	23.4	1200
No. 23				"	"	28.2	7.05	12.0	24.0	1500
and				"	"	32.3	8.07	12.9	25.8	2000
Calibration				"	"	34.2	8.55	13.35	26.7	2200
Curve				"	"	36.1	9.02	13.8	27.6	2500
Sheet				"	"	39.7	9.92	14.6	29.2	3000
No.4				"	"	38.0	9.50	14.2	28.4	3500
				"	"	33.3	8.32	13.15	26.3	4000
				"	"	24.7	6.17	11.1	22.2	4500
				"	"	18.1	4.52	9.45	18.9	5000
				"	"	8.4	2.1	6.1	12.2	6000
				"	"	4.6	1.15	4.25	8.5	7000
				"	"	2.9	.72	3.05	6.1	8000
				"	"	2.3	.57	2.35	4.7	9000
				"	"	1.8	.45	1.8	3.6	10000

REMARKS

° See Transformer Curve Sheet No. 12

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **34** Test No. **1** Sheet No. **38**

Amplifier Tube

Type **CX301a** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	3.0 a	.5 a	2.0	4.0	60
				"	"	3.0	.75	3.1	6.2	100
				"	"	9.0	2.25	6.35	12.7	200
				"	"	16.0	4.0	8.8	17.6	300
				"	"	28.7	7.17	12.05	24.1	400
				"	"	41.8	10.45	15.1	30.2	500
				"	"	3.0 b	.75b	19.7	39.4	700
				"	"	12.8	3.2	24.4	48.8	1000
				"	"	15.1	3.72	25.2	50.4	1200
See Data				"	"	17.2	4.3	25.9	51.8	1500
Sheet No. 23				"	"	9.8	2.45	23.25	46.5	2000
and				"	"	6.2	1.55	21.65	43.3	2200
Calibration				"	"	4.9	1.22	20.9	41.8	2500
Curve				"	"	1.0	.25	17.6	35.2	3000
Sheet				"	"	40.0 a	10.0 a	14.65	29.3	3500
No. 4				"	"	33.9	8.47	13.25	26.5	4000
				"	"	30.2	7.55	12.45	24.9	4500
				"	"	23.4	5.85	10.85	21.7	5000
				"	"	17.7	4.42	9.3	18.6	6000
				"	"	13.7	3.42	8.1	16.2	7000
				"	"	10.3	2.57	6.9	13.8	8000
				"	"	8.5	2.12	6.2	12.4	9000
				"	"	6.9	1.72	5.4	10.8	10000

REMARKS

° See Transformer Curve Sheet No. 5

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 35 Test No. 1 Sheet No. 39

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	3.5 a	.88a	3.5	7.0	60
				"	"	6.8	1.70	5.4	10.8	100
				"	"	17.8	4.45	9.35	18.7	200
				"	"	26.2	6.55	11.5	23.0	300
				"	"	32.0	8.00	12.85	25.7	400
				"	"	36.0	9.00	13.75	27.5	500
				"	"	40.5	10.13	14.8	29.6	700
				"	"	.5 b	.13b	16.6	33.2	1000
				"	"	.6	.15	16.8	33.6	1200
				"	"	.5	.13	16.6	33.2	1500
				"	"	45.8 a	11.45a	15.85	31.7	2000
				"	"	44.8	11.20	15.7	31.4	2200
See Data				"	"	43.7	10.93	15.45	30.9	2500
Sheet No. 23				"	"	40.0	10.00	14.65	29.3	3000
and				"	"	32.3	8.08	12.9	25.8	3500
Calibration				"	"	26.8	6.70	11.65	23.3	4000
Curve				"	"	23.0	5.75	10.75	21.5	4500
Sheet				"	"	18.7	4.68	9.6	19.2	5000
No. 4				"	"	13.8	3.20	7.8	15.6	6000
				"	"	8.7	2.18	6.3	12.6	7000
				"	"	6.0	1.50	5.0	10.0	8000
				"	"	4.7	1.18	4.3	8.6	9000
				"	"	3.2	.80	3.25	6.5	10000

REMARKS

°See Transformer Curve Sheet No. 2

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 36 Test No. 1 Sheet No. 40

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input° volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	5.9a	1.47a	4.95	9.9	60
				"	"	12.0	3.0	7.5	15.0	100
				"	"	28.8	7.2	12.1	24.2	200
				"	"	40.6	10.15	14.8	29.6	300
				"	"	.8b	.2	b17.25	34.5	400
				"	"	2.0	.5	18.85	37.7	500
				"	"	2.6	.65	19.4	38.8	700
				"	"	3.0	.75	19.7	39.4	1000
				"	"	2.5	.62	19.3	38.6	1200
See	Data	Sheet		"	"	2.4	.6	19.2	38.4	1500
	No. 23			"	"	1.4	.35	18.2	36.4	2000
	and			"	"	1.3	.32	18.1	36.2	2200
Calibration				"	"	.9	.22	17.5	35.0	2500
Curve				"	"	.4	.1	16.25	32.5	3000
	Sheet	No. 4		"	"	39.2a	9.8	a14.5	29.0	3500
				"	"	35.2	8.8	13.6	27.2	4000
				"	"	27.9	6.97	11.9	23.8	4500
				"	"	24.8	6.2	11.15	22.3	5000
				"	"	20.1	5.02	9.95	19.9	6000
				"	"	13.7	3.42	8.1	16.2	7000
				"	"	11.6	2.9	7.4	14.8	8000
				"	"	8.7	2.17	6.25	12.5	9000
				"	"	6.7	1.67	5.46	10.9	10000

REMARKS

° See Transformer Curve Sheet No. 9

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 37 Test No. 1 Sheet No. 41

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output				
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts	$E2/E1$	
E	I_p		I_p		E_1	I_p		E_2	E_a	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325	.5	1.9 a	.47a	1.8	3.6	60
				"	"	2.3	.57	2.3	4.6	100
				"	"	3.7	.92	3.65	7.3	200
				"	"	4.3	1.07	4.05	8.1	300
				"	"	4.85	1.21	4.4	8.8	400
				"	"	5.3	1.32	4.65	9.3	500
				"	"	5.6	1.4	4.8	9.6	700
				"	"	5.9	1.47	4.98	9.9	1000
See Data Sheet				"	"	6.0	1.5	5.0	10.0	1200
No. 23				"	"	6.1	1.52	5.05	10.1	1500
and				"	"	6.25	1.56	5.1	10.2	2000
Calibration				"	"	6.4	1.6	5.2	10.4	2200
Curve				"	"	6.6	1.65	5.3	10.6	2500
No. 4				"	"	6.4	1.6	5.2	10.4	3000
				"	"	6.2	1.55	5.15	10.3	3500
				"	"	6.3	1.57	5.15	10.3	4000
				"	"	6.2	1.55	5.15	10.3	4500
				"	"	6.4	1.6	5.2	10.4	5000
				"	"	6.6	1.65	5.3	10.3	6000
				"	"	6.5	1.62	5.3	10.3	7000
				"	"	6.9	1.72	5.45	10.9	8000
				"	"	7.2	1.8	5.6	11.2	9000
				"	"	7.6	1.9	5.75	11.4	10000

REMARKS

° See Transformer Curve Sheet No. 9

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 38 Test No. 1 Sheet No. 42

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325	.5	6.4 a	1.6 a	5.2	10.4	60
				"	"	12.7	3.17	7.75	15.5	100
				"	"	26.3	6.57	11.5	23.0	200
				"	"	33.6	8.4	13.2	26.4	300
				"	"	39.6	9.9	14.55	29.1	400
				"	"	43.9	10.97	15.45	30.9	500
				"	"	[illegible]	.17	16.95	33.9	700
				"	"	[illegible]	.26	17.7	35.4	1000
See Data Sheet				"	"	[illegible]	.30	17.9	35.8	1200
No. 23				"	"	[illegible]	.29	17.85	35.7	1500
and				"	"	[illegible]	.26	17.7	35.4	2000
Calibration				"	"	[illegible]	.26	17.7	35.4	2200
Curve				"	"	[illegible]	.24	17.6	35.2	2500
Sheet No. 4				"	"	48.0a	12.0 a	16.3	32.6	3000
				"	"	47.0	11.75	16.1	32.2	3500
				"	"	45.0	11.25	15.7	31.4	4000
				"	"	42.0	10.5	15.1	30.2	4500
				"	"	38.5	9.62	14.25	28.5	5000
				"	"	32.0	8.0	12.85	25.7	6000
				"	"	26.0	6.5	11.45	22.9	7000
				"	"	18.1	4.52	9.2	18.4	8000
				"	"	14.4	3.6	8.8	17.6	9000
				"	"	10.5	2.62	7.0	14.0	10000

REMARKS

° See Transformer Curve Sheet No. 9

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 39 Test No. 1 Sheet No. 43

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output			E2 / E1	
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	3.9a	.97a	3.75	7.5	60
				"	"	4.2	1.05	4.0	8.0	100
				"	"	9.2	2.3	6.5	13.0	200
				"	"	14.6	3.65	8.4	16.8	300
				"	"	16.6	4.15	9.0	18.0	400
				"	"	18.0	4.5	9.4	18.8	500
				"	"	20.5	5.12	10.05	20.1	700
				"	"	22.6	5.65	10.6	21.2	1000
				"	"	23.5	5.87	10.85	21.7	1200
				"	"	24.3	6.075	11.05	22.1	1500
See Data Sheet				"	"	25.5	6.37	11.3	22.6	2000
No. 23				"	"	26.8	6.7	11.6	23.2	2200
and				"	"	26.0	6.5	11.45	22.9	2500
Calibration				"	"	25.8	6.45	11.4	22.8	3000
Curve Sheet				"	"	25.8	6.45	11.4	22.8	3500
No. 4				"	"	24.7	6.17	11.1	22.2	4000
				"	"	24.0	6.0	10.95	21.9	4500
				"	"	23.0	5.75	10.7	21.4	5000
				"	"	21.0	5.02	10.0	20.0	6000
				"	"	20.0	5.0	9.95	19.9	7000
				"	"	18.9	4.72	9.65	19.3	8000
				"	"	17.5	4.37	9.2	18.4	9000
				"	"	16.0	4.0	8.8	17.6	10000

REMARKS

° See Transformer Curve Sheet No. 9

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 40 Test No. 1 Sheet No. 44

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						E2/E1	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	6.5a	1.62a	5.3	10.6	60
				"	"	10.5a	2.62	7.0	14.0	100
				"	"	18.4	4.6	9.5	19.0	200
				"	"	20.8	5.2	10.15	20.3	300
				"	"	24.3	6.07	11.05	22.1	400
				"	"	25.0	6.25	11.2	22.4	500
				"	"	26.2	6.55	11.5	23.0	700
				"	"	27.2	6.8	11.7	23.4	1000
				"	"	27.6	6.9	11.8	23.6	1200
				"	"	29.4	7.35	12.25	24.5	1500
See Data Sheet				"	"	31.0	7.75	12.6	25.2	2000
No. 23				"	"	31.3	7.82	12.7	25.4	2200
and				"	"	31.8	7.95	12.8	25.6	2500
Calibration				"	"	34.4	8.6	13.4	26.8	3000
Curve				"	"	36.2	9.05	13.8	27.6	3500
Sheet				"	"	39.5	9.87	14.55	29.1	4000
No. 4				"	"	41.8	10.45	15.1	30.2	4500
				"	"	43.5	10.87	15.4	30.8	5000
				"	"	41.6	10.4	15.0	30.0	6000
				"	"	34.0	8.5	13.3	26.6	7000
				"	"	23.0	5.75	10.7	21.4	8000
				"	"	15.0	3.75	8.5	17.0	9000
				"	"	9.6	2.4	6.6	13.2	10000

REMARKS

* See Transformer Curve Sheet No. 14

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **41** Test No. **1** Sheet No. **45**

Amplifier Tube

Type **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output			$E2/E1$	
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	3.4 a	.85a	3.4	6.8	60
				"	"	4.6	1.15	4.25	8.5	100
				"	"	7.2	1.8	5.6	11.2	200
				"	"	8.2	2.05	6.05	12.1	300
				"	"	8.8	2.2	6.3	12.6	400
				"	"	10.3	2.57	6.85	13.7	500
				"	"	10.4	2.6	6.95	13.9	700
See Data Sheet				"	"	10.8	2.7	7.1	14.2	1000
No. 23				"	"	10.7	2.67	7.1	14.2	1200
and				"	"	11.2	2.8	7.25	14.5	1500
Calibration				"	"	11.7	2.92	7.4	14.8	2000
Curve				"	"	12.2	3.05	7.6	15.2	2200
Sheet No. 4				"	"	12.6	3.15	7.75	15.5	2500
				"	"	13.2	3.3	7.9	15.8	3000
				"	"	13.8	3.45	8.15	16.3	3500
				"	"	16.1	4.02	8.8	17.6	4000
				"	"	17.3	4.32	9.2	18.4	4500
				"	"	18.7	4.67	9.55	19.1	5000
				"	"	22.2	5.55	10.5	21.0	6000
				"	"	23.9	5.97	10.95	21.9	7000
				"	"	34.1	8.52	13.3	26.6	8000
				"	"	42.4	10.6	15.2	30.4	9000
				"	"	42.6	10.65	15.25	30.5	10000

REMARKS

* See Transformer Curve Sheet No. 14

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 42 Test No. 1 Sheet No. 46

Amplifier Tube

Type CX301A No.4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	7.4 a	1.85a	5.7	11.4	60
				"	"	15.4	3.85	8.6	17.2	100
				"	"	32.0	8.0	12.85	25.7	200
				"	"	41.0	10.25	14.85	29.7	300
				"	"	47.3	11.82	16.15	32.3	400
				"	"	[illegible]	.31b	18.0	36.0	500
				"	"		.37	18.3	36.6	700
				"	"		.39	18.35	36.7	1000
				"	"		.34	18.2	36.4	1200
				"	"		.27	17.75	35.5	1500
				"	"	47.6 a	11.9 a	16.2	32.4	2000
See	Data Sheet			"	"	44.4	11.1	15.6	31.2	2200
	No. 23			"	"	41.3	10.32	14.95	29.9	2500
	and			"	"	38.7	9.67	14.35	28.7	3000
Calibration				"	"	35.1	8.77	13.55	27.1	3500
Curve				"	"	30.3	7.57	12.45	24.9	4000
	Sheet	No. 4		"	"	25.2	6.3	11.25	22.5	4500
				"	"	22.1	5.52	10.5	21.0	5000
				"	"	14.2	3.55	8.25	16.5	6000
				"	"	9.9	2.47	6.7	13.4	7000
				"	"	6.4	1.6	5.2	10.4	8000
				"	"	4.7	1.17	4.25	8.5	9000
				"	"	3.3	.82	3.3	6.6	10000

REMARKS

* See Transformer Curve Sheet No. 2

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 43 Test No. 1 Sheet No. 47

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B = 90 volts; E_C = 4.5 volts; E_F = 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a O	f
k=1	k=	k=1	k=	k=1	k=1	k=25	k=1	k=1		
				.325a	.5	22.0a	5.5 a	10.45	20.9	60
				"	"	29.2	7.3	12.2	24.4	100
				"	"	42.6	10.65	15.2	30.4	200
				"	"	46.7	11.67	16.0	32.0	300
				"	"		.15b	16.8	33.6	400
				"	"		.24	17.6	35.2	500
				"	"		.33	18.1	36.2	700
				"	"		.47	18.7	37.4	1000
				"	"		.51	18.95	37.9	1200
See	Data Sheet			"	"	3.4 b	.85	19.95	39.9	1500
	No. 23			"	"	6.4	1.6	21.7	43.4	2000
	and			"	"	7.1	1.77	22.5	45.0	2200
Calibration				"	"	6.1	1.52	21.6	43.2	2500
	Curve			"	"	3.4	.85	19.95	39.9	3000
	Sheet No. 4			"	"		.25	17.65	35.3	3500
				"	"	34.6 a	8.65a	13.45	26.9	4000
				"	"	19.7	4.92	9.85	19.7	4500
				"	"	13.2	3.3	7.9	15.8	5000
				"	"	6.0	1.5	5.0	10.0	6000
				"	"	3.0	.75	3.1	6.2	7000
				"	"	2.1	.52	2.2	4.4	8000
				"	"	1.6	.4	1.5	3.0	9000
				"	"	1.3	.32	.7	1.4	10000

REMARKS

O See Transformer Curve Sheet No. 29

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **44** Test No. **1** Sheet No. **48**

Amplifier Tube

Type **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	11.0a	2.75a	7.15	14.3	60
				"	"	19.0	4.75	9.65	19.3	100
				"	"	29.1	7.27	12.15	24.3	200
				"	"	37.6	9.4	14.15	28.3	300
				"	"	42.0	10.5	15.1	30.2	400
				"	"	44.9	11.22	15.7	31.4	500
				"	"	45.6	11.4	15.85	31.7	700
See Data Sheet				"	"	45.7	11.42	15.85	31.7	1000
No. 23				"	"	45.5	11.37	15.8	31.6	1200
and				"	"	45.4	11.35	15.8	31.6	1500
Calibration				"	"	46.5	11.62	16.0	32.0	2000
Curve				"	"	47.0	11.75	16.1	32.2	2200
Sheet				"	"	47.0	11.75	16.1	32.2	2500
No. 4				"	"	46.4	11.6	16.0	32.0	3000
				"	"	40.6	10.15	14.8	29.6	3500
				"	"	36.7	9.17	13.9	27.8	4000
				"	"	33.2	8.3	13.1	26.2	4500
				"	"	31.0	7.75	12.6	25.2	5000
				"	"	19.0	4.75	9.65	19.3	6000
				"	"	12.8	3.2	7.8	15.6	7000
				"	"	8.2	2.05	6.05	12.1	8000
				"	"	5.7	1.42	4.9	9.8	9000
				"	"	3.9	.97	3.8	7.6	10000

REMARKS

* See Transformer Curve Sheet No. 5

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **45** Test No. **1** Sheet No. **49**

Amplifier Tube

Type **CX301A** No. Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	5.3a	1.33a	4.65	9.3	60
				"	"	10.0	2.5	6.8	13.8	100
				"	"	21.0	5.25	10.2	20.4	200
				"	"	28.0	7.00	11.9	23.8	300
				"	"	30.0	7.5	12.4	24.8	400
				"	"	33.5	8.38	13.2	26.4	500
				"	"	40.0	10.0	14.65	29.3	700
				"	"	40.7	10.18	14.8	29.6	1000
				"	"	42.0	10.5	15.1	30.2	1200
				"	"	45.0	11.25	15.7	31.4	1500
				"	"	46.0	11.5	15.9	31.8	2000
				"	"	46.7	11.68	16.05	32.1	2200
				"	"	47.4	11.85	16.15	32.3	2500
See Data Sheet				"	"	48.3	12.08	16.35	32.7	3000
No. 23				"	"	[illegible]	.31b	18.0	36.0	3500
and				"	"	[illegible]	.28	17.8	35.6	4000
Calibration				"	"	[illegible]	.26	17.65	35.3	4500
Curve				"	"	[illegible]	.24	17.55	35.1	5000
Sheet				"	"	41.3a	10.33a	14.95	29.9	6000
No. 4				"	"	27.3	6.83	11.75	23.5	7000
				"	"	17.7	4.43	9.3	18.6	8000
				"	"	11.5	2.88	7.35	14.7	9000
				"	"	7.7	1.93	5.8	11.6	10000

REMARKS

°See Transformer Curve Sheet No. 25

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 46 Test No. 1 Sheet No. 50

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
			Input			Output				
Input volts *	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	* f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325	.5	8.0	2.0	5.95	11.9	60
				"	"	9.9	2.47	6.75	13.5	100
				"	"	10.3	2.57	6.85	13.7	200
				"	"	10.8	2.7	7.1	14.2	300
				"	"	11.0	2.75	7.15	14.3	400
				"	"	11.0	2.75	7.15	14.3	500
				"	"	11.3	2.82	7.25	14.5	700
				"	"	11.4	2.85	7.3	14.6	1000
See Data Sheet										
No. 23				"	"	12.0	3.0	7.5	15.0	1500
and				"	"	13.2	3.3	7.9	15.8	2000
Calibration										
Curve				"	"	14.6	3.65	8.35	16.7	2500
Sheet				"	"	16.3	4.07	8.95	17.9	3000
No. 4				"	"	18.2	4.55	9.45	18.9	3500
				"	"	23.9	5.97	10.95	21.9	4000
				"	"	29.8	7.45	12.35	24.7	4500
				"	"	39.1	9.77	14.45	28.9	5000
				"	"	46.6	11.65	16.0	32.0	6000
				"	"	39.3	9.82	14.5	29.0	6500
				"	"	28.3	7.17	12.05	24.1	7000
				"	"	13.6	3.4	8.1	16.2	8000
				"	"	6.6	1.65	5.3	10.6	9000
				"	"	3.8	.95	3.7	7.4	10000

REMARKS

* See Transformer Curve Sheet No. 7

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **47** Test No. **1** Sheet No. **51**

Amplifier Tube

Type **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output			$E2/E1$	
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	9.3a	2.32a	6.5	13.0	60
				"	"	9.5	2.37	6.58	13.2	100
				"	"	10.1	2.52	6.81	13.6	200
				"	"	10.0	2.50	6.8	13.6	300
				"	"	10.1	2.52	6.81	13:6	400
				"	"	10.4	2.60	6.9	13.8	500
				"	"	10.8	2.7	7.1	14.2	700
				"	"	10.9	2.72	7.15	14.3	1000
				"	"	11.0	2.75	7.15	14.3	1500
See Data Sheet				"	"	12.0	3.0	7.5	15.0	2000
No. 23										
and				"	"	13.1	3.27	7.9	15.8	2500
Calibration				"	"	15.0	3.75	8.5	17.0	3000
Curve				"	"	17.1	4.27	9.1	18.2	3500
Sheet				"	"	20.2	5.05	9.8	19.6	4000
No. 4				"	"	25.4	6.35	11.3	22.6	4500
				"	"	33.5	8.37	13.2	26.4	5000
				"	"	40.0	10.0	14.65	29.3	6000
				"	"	33.2	8.3	13.1	26.2	6500
				"	"	25.7	6.42	11.4	22.8	7000
				"	"	12.6	3.15	7.75	15.5	8000
				"	"	6.0	1.5	5.0	10.0	9000
				"	"	3.5	.87	3.4	6.8	10000

REMARKS

* See Transformer Curve Sheet No. 7

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 1_b Sheet No. 52

Amplifier Tube

Type UX201 No. 5 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						E2/E1	
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a*	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	19.7a	4.92a	9.85	19.7	60
				"	"	22.8	5.7	10.7	21.4	100
				"	"	23.4	5.85	10.85	21.7	200
				"	"	25.5	6.35	11.3	22.6	300
				"	"	25.6	6.4	11.35	22.7	400
				"	"	25.9	6.47	11.4	22.8	500
				"	"	26.3	6.57	11.5	23.0	700
				"	"	26.8	6.7	11.6	23.2	1000
				"	"	26.2	6.55	11.5	23.0	1200
				"	"	26.0	6.5	11.45	22.9	1500
				"	"	27.0	6.75	11.65	23.3	2000
				"	"	28.0	7.0	11.9	23.8	2200
See Data Sheet				"	"	28.4	7.1	12.0	24.0	2500
No. 23				"	"	29.0	7.25	12.15	24.3	3000
and				"	"	30.6	7.65	12.55	25.1	3500
Calibration				"	"	31.7	7.95	12.8	25.6	4000
Curve				"	"	32.0	8.0	12.85	25.7	4500
Sheet				"	"	30.0	7.5	12.4	24.8	5000
No. 4				"	"	25.0	6.25	11.2	22.4	6000
				"	"	22.8	5.7	10.65	21.3	7000
				"	"	16.1	4.02	8.85	17.7	8000
				"	"	10.8	2.7	7.1	14.2	9000
				"	"	7.2	1.8	5.6	11.2	10000

REMARKS

* See Transformer Curve Sheet No. 23

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 6 Sheet No. 53

Amplifier Tube

Type CX299 No. 1 Voltages:— E_B=90 volts; E_C=4.5 volts; E_F= 3 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	10.8a	2.7 a	7.1	14.2	60
				"	"	13.4	3.35	8.0	16.0	100
				"	"	15.6	3.7	8.45	16.9	200
				"	"	16.3	4.07	8.9	17.8	300
				"	"	16.1	4.02	8.85	17.7	400
				"	"	16.5	4.12	8.95	17.9	500
				"	"	16.7	4.17	9.0	18.0	700
				"	"	16.6	4.15	9.0	18.0	1000
				"	"	16.8	4.2	9.05	18.1	1200
				"	"	17.0	4.25	9.1	18.2	1500
				"	"	16.5	4.12	8.95	17.9	2000
See Data Sheet				"	"	16.4	4.1	8.95	17.9	2200
No. 23				"	"	16.7	4.17	9.0	18.0	2500
and				"	"	16.5	4.12	8.95	17.9	3000
Calibration				"	"	15.6	3.9	8.7	17.4	3500
Curve				"	"	15.0	3.75	8.5	17.0	4000
Sheet No. 4				"	"	13.9	3.47	8.15	16.3	4500
				"	"	12.4	3.1	7.7	15.4	5000
				"	"	10.9	2.72	7.1	14.2	6000
				"	"	10.1	2.52	6.85	13.7	7000
				"	"	8.1	2.02	6.0	12.0	8000
				"	"	6.0	1.5	5.0	10.0	9000
				"	"	4.4	1.1	4.1	8.2	10000

REMARKS

* See Transformer Curve Sheet No. 23

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 6a Sheet No. 54

Amplifier Tube

Type UX299 No. 2 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 3 volts

VACUUM TUBE VOLTMETER									Voltage amplification E_2/E_1	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	12.0a	3.0 a	7.5	15.0	60
				"	"	17.2	4.3	9.15	18.3	100
				"	"	19.4	4.85	9.75	19.5	200
				"	"	19.9	4.97	9.9	19.8	300
				"	"	20.3	5.07	10.0	20.0	400
				"	"	20.0	5.0	9.95	19.9	500
				"	"	20.4	5.1	10.05	20.1	700
See Data Sheet				"	"	20.3	5.07	10.00	20.0	1000
No. 23				"	"	20.3	5.07	10.0	20.0	1200
and				"	"	19.9	4.97	9.9	19.8	1500
Calibration				"	"	18.2	4.55	9.45	18.9	2000
Curve				"	"	17.6	4.4	9.3	18.6	2200
Sheet				"	"	16.8	4.2	9.05	18.1	2500
No. 4				"	"	16.0	4.0	8.8	17.6	3000
				"	"	14.4	3.8	8.6	17.2	3500
				"	"	13.7	3.42	8.1	16.2	4000
				"	"	12.1	3.02	7.5	15.0	4500
				"	"	11.1	2.77	7.15	14.3	5000
				"	"	9.7	2.42	6.65	13.3	6000
				"	"	9.4	2.35	6.55	13.1	7000
				"	"	7.2	1.8	5.6	11.2	8000
				"	"	5.9	1.47	4.95	9.9	9000
				"	"	4.5	1.12	4.2	8.4	10000

REMARKS

* See Transformer Curve Sheet No. 23

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 9 Sheet No. 55

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B=90 volts; E_C=4.5 volts; E_F=5 volts

VACUUM TUBE VOLTMETER										Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							$E2/E1$	
			Input			Output					
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts			
E	I_p		I_p		E_1	I_p		E_2		E_a	° f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1			
				.325a	.5	19.1 a	4.77a	11.55		23.1	60
				"	"	18.5	4.63	11.35		22.7	100
				"	"	20.3	5.07	11.85		23.7	200
				"	"	21.0	5.25	12.1		24.2	300
				"	"	21.5	5.37	12.25		24.5	400
				"	"	22.3	5.57	12.5		25.0	500
				"	"	21.8	5.45	12.35		24.7	700
				"	"	21.1	5.27	12.1		24.2	1000
				"	"	22.8	5.70	12.6		25.2	1200
				"	"	23.8	5.95	12.95		25.9	1500
See Data Sheet				"	"	24.9	6.22	13.2		26.4	2000
	No. 23			"	"	25.9	6.47	13.5		27.0	2200
	and			"	"	27.1	6.77	13.85		27.7	2500
Calibration				"	"	27.9	6.97	14.05		28.1	3000
	Curve			"	"	28.7	7.17	14.25		28.5	3500
	Sheet			"	"	30.4	7.60	14.75		29.5	4000
	No. 4			"	"	30.3	7.57	14.7		29.4	4500
				"	"	25.3	6.42	13.45		26.9	5000
				"	"	20.8	5.20	12.05		24.1	6000
				"	"	19.6	4.90	11.7		23.4	7000
				"	"	11.8	2.45	8.3		16.6	8000
				"	"	7.2	1.80	7.15		14.3	9000
				"	"	4.6	1.15	5.75		11.5	10000

REMARKS

° See Transformer Curve Sheet No. 22

VOLTAGE AMPLIFICATION TEST DATA SHEET

ansformer No. **48** Test No. **1** Sheet No. **56**

Amplifier Tube

ype **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
nput volts	Plate current in milliamperes		Input			Output			$E2/E1$	
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	3.2a	.8a	3.25	6.5	60
				"	"	5.8	1.45	4.9	9.8	100
				"	"	11.0	2.75	7.15	14.3	200
				"	"	13.6	3.4	8.1	16.2	300
				"	"	16.5	4.25	9.1	18.2	400
				"	"	17.1	4.27	9.15	18.3	500
				"	"	18.0	4.5	9.4	18.8	700
				"	"	19.1	4.77	9.7	19.4	1000
				"	"	20.8	5.2	10.15	20.3	1200
				"	"	24.5	6.12	11.1	22.2	1500
				"	"	31.8	7.9	12.75	25.5	2000
See Data Sheet				"	"	33.0	8.25	13.2	26.4	2200
No. 23				"	"	41.0	10.25	14.9	29.8	2500
and				"	"	1.7b	.42b	18.6	37.2	3000
Calibration				"	"	5.9	1.47	21.45	42.9	3500
Curve				"	"	3.0	.75	19.7	39.4	4000
Sheet				"	"	35.6a	8.9	a13.7	27.4	4500
No. 4				"	"	18.1	4.52	9.6	19.2	5000
				"	"	6.8	1.7	5.4	10.8	6000
				"	"	3.8	.95	3.7	7.4	7000
				"	"	2.3	.57	2.3	4.6	8000
				"	"	2.0	.5	2.0	4.0	9000
				"	"	1.8	.45	1.8	3.6	10000

REMARKS

* See Transformer Curve Sheet No. 24

VOLTAGE AMPLIFICATION TEST DATA SHEET

ransformer No. 49 Test No. 1 Sheet No. 57

Amplifier Tube

ype CX301A No. 4 Voltages:— E_B=90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
nput volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	1.3a	.325a	.5	1.0	60
				"	"	4.1	1.025	3.9	7.8	100
				"	"	9.7	2.425	6.65	13.3	200
				"	"	12.7	3.175	7.75	15.5	300
				"	"	16.4	4.10	8.95	17.9	400
				"	"	17.3	4.325	9.2	18.4	500
				"	"	19.3	4.825	9.75	19.5	700
				"	"	21.0	5.25	10.20	20.4	1000
				"	"	24.0	6.0	11.0	22.0	1200
				"	"	25.5	6.375	11.3	22.6	1500
				"	"	30.8	7.70	12.55	25.1	2000
See Data Sheet				"	"	34.4	8.60	13.4	26.8	2200
No. 23				"b	"	44.6	11.15	15.65	31.3	2500
and				"	"	2.4b	.60b	19.2	38.4	3000
Calibration				"	"	8.0	2.0	20.95	41.9	3500
Curve Sheet				"	"	2.2	.54	19.0	38.0	4000
No. 4				"	"	33.5a	8.375a	13.2	26.4	4500
				"	"	17.8	4.45	9.35	18.7	5000
				"	"	6.5	1.625	5.3	10.6	6000
				"	"	3.3	.825	3.3	6.6	7000
				"	"	2.2	.55	2.3	4.6	8000
				"	"		.44	1.7	3.4	9000
				"	"		.375	1.1	2.2	10000

REMARKS

* See Transformer Curve Sheet No. 24

VOLTAGE AMPLIFICATION TEST DATA SHEET

ansformer No. 50° Test No. 1 Sheet No. 58

Amplifier Tube

ype CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
nput olts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	17.3 a	4.32a	9.2	18.4	60
				"	"	22.8	5.7	10.7	21.4	100
				"	"	27.7	6.93	11.9	23.8	200
				"	"	29.0	7.25	12.25	24.5	300
				"	"	29.1	7.27	12.3	24.6	400
				"	"	29.3	7.32	12.3	24.6	500
				"	"	29.3	7.32	12.3	24.6	700
				"	"	29.4	7.35	12.35	24.7	1000
See Data Sheet				"	"	29.2	7.3	12.3	24.6	1200
No. 23				"	"	29.7	7.42	12.4	24.8	1500
and				"	"	29.4	7.35	12.35	24.7	2000
Calibration				"	"	29.0	7.25	12.25	24.5	2200
Curve				"	"	28.0	7.0	12.0	24.0	2500
Sheet				"	"	27.2	6.8	11.8	23.6	3000
No. 4				"	"	25.6	6.4	11.4	22.8	3500
				"	"	25.1	6.27	11.3	22.6	4000
				"	"	24.5	6.12	11.15	22.3	4500
				"	"	20.8	5.2	10.15	20.3	5000
				"	"	11.4	2.85	7.3	14.6	6000
				"	"	5.2	1.3	4.6	9.2	7000
				"	"	2.6	.65	2.75	5.5	8000
				"	"	1.7	.42	1.7	3.4	9000
				"	"	1.2	.3	-	-	10000

REMARKS

See Transformer Curve Sheet No. 26

Connections made to transformer from outside of receiver

VOLTAGE AMPLIFICATION TEST DATA SHEET

ansformer No. 51° Test No. 1 Sheet No. 59

Amplifier Tube

pe **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output				
nput olts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1	*	
				.325a	.5	17.9a	4.47a	9.35	18.7	60
				"	"	24.3	6.07	11.1	22.2	100
				"	"	27.1	6.77	11.75	23.5	200
				"	"	27.3	6.82	11.8	23.6	300
				"	"	28.2	7.05	12.05	24.1	400
				"	"	29.3	7.32	12.3	24.6	500
				"	"	30.3	7.57	12.55	25.1	700
See Data Sheet				"	"	30.3	7.57	12.55	25.1	1000
No. 23				"	"	30.4	7.6	12.6	25.2	1200
and				"	"	30.8	7.7	12.7	25.4	1500
Calibration				"	"	32.0	8.0	12.95	25.9	2000
Curve				"	"	32.0	8.0	12.95	25.9	2200
Sheet				"	"	31.7	7.92	12.85	25.7	2500
No. 4				"	"	32.1	8.02	12.95	25.9	3000
				"	"	31.9	7.97	12.9	25.8	3500
				"	"	29.7	7.42	12.4	24.8	4000
				"	"	23.1	5.77	10.8	21.6	4500
				"	"	21.0	5.25	10.25	20.5	5000
				"	"	10.0	2.5	6.8	13.6	6000
				"	"	5.5	1.37	4.7	9.4	7000
				"	"	3.3	.82	3.3	6.6	8000
				"	"	2.0	.5	2.0	4.0	9000
				"	"	1.7	.42	1.7	3.4	10000

REMARKS

* See Transformer Curve Sheet No. 26

° Connections made to transformer from outside of receiver.

VOLTAGE AMPLIFICATION TEST DATA SHEET

ansformer No. 52 Test No. 1 Sheet No. 60

Amplifier Tube

ype CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER										Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.								
nput olts	Plate current in milliamperes		Input			Output					
			milliamperes		equiv. volts	milliamperes		equiv. volts			
E	I_p		I_p		E_1	I_p		E_2		E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1			
				.325a	.5	5.0a	1.25	4.45		8.9	60
				"	"	8.2	2.05	6.05		12.1	100
				"	"	15.0	3.75	8.50		17.0	200
				"	"	18.0	4.50	9.40		18.8	300
				"	"	20.8	5.20	10.15		20.3	400
				"	"	22.7	5.67	10.65		20.7	500
				"	"	23.3	5.82	10.80		21.6	700
				"	"	25.0	6.25	11.2		22.4	1000
	See Data Sheet			"	"	26.5	6.62	11.55		23.1	1200
	No. 23			"	"	26.5	6.62	11.55		23.1	1500
	and			"	"	28.0	7.00	11.90		23.8	2000
	Calibration			"	"	28.0	7.00	11.90		23.8	2200
	Curve			"	"	29.8	7.45	12.35		24.7	2500
	Sheet			"	"	30.4	7.60	12.5		25.0	3000
	No. 4			"	"	32.7	8.17	13.5		27.0	3500
				"	"	35.00	8.75	13.55		27.1	4000
				"	"	38.4	9.60	14.3		28.6	4500
				"	"	39.8	9.95	14.6		29.2	5000
				"	"	45.0	11.25	15.7		31.4	6000
				"	"	41.0	10.25	14.9		29.8	7000
				"	"	34.4	8.60	13.4		26.8	8000
				"	"	24.0	6.00	11.0		22.0	9000
				"	"	16.0	4.00	8.8		17.6	10000

REMARKS

* See Transformer Curve Sheet No. 27

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 7 Sheet No. 61

Amplifier Tube

Type CX299 No. 1 Voltages:— E_B= 67.5 volts; E_C= 1.5 volts; E_F= 3 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts	E2/E1	
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	10.3a	2.58a	6.9	13.8	60
				"	"	11.2	2.8	7.2	14.4	100
				"	"	12.1	3.03	7.55	15.1	200
				"	"	14.0	3.5	8.2	16.4	300
				"	"	14.7	3.68	8.4	16.8	400
				"	"	14.2	3.55	8.25	16.5	500
				"	"	14.9	3.75	8.5	17.0	700
				"	"	14.2	3.55	8.25	16.5	1000
				"	"	13.9	3.48	8.15	16.3	1500
				"	"	12.7	3.18	7.75	15.5	2000
See Data Sheet				"	"	11.9	2.98	7.5	15.0	2500
No. 23				"	"	11.5	2.88	7.35	14.7	3000
and				"	"	10.7	2.68	7.05	14.1	3500
Calibration				"	"	9.7	2.43	6.7	13.4	4000
Curve				"	"	8.7	2.18	6.25	12.5	4500
Sheet				"	"	7.4	1.85	5.65	11.3	5000
No. 4				"	"	6.5	1.63	5.25	10.5	6000
				"	"	6.1	1.53	5.0	10.0	7000
				"	"	5.1	1.28	4.5	9.0	8000
				"	"	3.9	.98	3.8	7.6	9000
				"	"	3.0	.75	3.05	6.1	10000

REMARKS

* See Transformer Curve Sheet No. 31

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 8 Sheet No. 62

Amplifier Tube

Type CX299 No. 1 Voltages:— E_B=67.5 volts; E_C=3 volts; E_F= 3 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output			$E2/E1$	
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	* f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	9.2 a	2.3	6.45	12.9	60
				"	"	10.9	2.72	7.1	14.2	100
				"	"	13.2	3.3	7.9	15.8	200
				"	"	14.0	3.5	8.2	16.4	300
				"	"	14.3	3.57	8.25	16.5	400
				"	"	14.8	3.7	8.4	16.8	500
				"	"	14.6	3.65	8.35	16.7	700
				"	"	13.6	3.4	8.05	16.1	1000
				"	"	13.4	3.35	8.0	16.0	1200
				"	"	12.6	3.15	7.7	15.4	1500
				"	"	11.7	2.92	7.4	14.8	2000
See Data Sheet				"	"	10.4	2.6	6.9	13.8	2500
No. 23				"	"	9.1	2.27	6.4	12.8	3000
and				"	"	8.1	2.02	6.0	12.0	3500
Calibration				"	"	7.0	1.75	5.5	11.0	4000
Curve				"	"	6.0	1.5	5.0	10.0	4500
Sheet				"	"	5.5	1.37	4.7	9.4	5000
No. 4				"	"	4.9	1.22	4.4	8.8	6000
				"	"	4.7	1.17	4.25	8.5	7000
				"	"	4.0	1.0	3.9	7.8	8000
				"	"	3.3	.82	3.4	6.8	9000
				"	"	2.9	.72	2.95	5.9	10000

REMARKS

* See Transformer Curve Sheet No. 21

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 11 Sheet No. 63

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.354a	1.0	2.2b	.55b	19.05	19.05	60
				"	"	4.2	1.05	20.35	20.35	100
				"	"	4.9	1.23	20.85	20.85	200
				"	"	5.3	1.33	21.05	21.05	300
				"	"	5.2	1.30	21.00	21.00	400
				"	"	5.5	1.38	21.15	21.15	500
				"	"	5.8	1.45	21.30	21.30	700
				"	"	6.0	1.50	21.45	21.45	1000
				"	"	6.2	1.55	21.50	21.50	1500
				"	"	7.1	1.78	21.95	21.95	2000
See Data Sheet				"	"	8.0	2.00	22.40	22.40	2500
No. 23				"	"	8.9	2.23	22.85	22.85	3000
and				"	"	9.1	2.28	22.90	22.90	3500
Calibration				"	"	8.9	2.23	22.85	22.85	4000
Curve				"	"	7.0	1.75	21.90	21.90	4500
Sheet No. 4				"	"	5.2	1.30	21.00	21.00	5000
				"	"	1.2	.30	17.95	17.95	6000
				"	"	38.1a	9.53a	14.25	14.25	7000
				"	"	25.2	6.30	11.30	11.30	8000
				"	"	16.8	4.20	9.00	9.00	9000
				"	"	11.9	2.98	7.45	7.45	10000

REMARKS

* See Transformer Curve Sheet No. 23

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 1 Sheet No. 64

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C=4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output				
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=25	k=1	k=1		
				.325a	.5	17.8a	4.45a	9.35	18.7	60
				"	"	20.4	5.1	10.05	20.1	100
				"	"	21.3	5.32	10.3	20.6	200
				"	"	23.0	5.75	10.75	21.5	300
				"	"	22.9	5.72	10.7	21.4	400
				"	"	23.8	5.95	10.95	21.9	500
				"	"	23.5	5.87	10.9	21.8	700
See Data Sheet				"	"	23.6	5.9	10.9	21.8	1000
No. 23										
and				"	"	23.8	5.95	10.95	21.9	1500
Calibration				"	"	24.0	6.0	11.0	22.0	2000
Curve				"	"	25.2	6.3	11.3	22.6	2200
Sheet				"	"	26.6	6.65	11.65	23.3	2500
No. 4				"	"	28.8	7.2	12.2	24.4	3000
				"	"	29.5	7.37	12.35	24.7	3500
				"	"	30.2	7.55	12.55	25.1	4000
				"	"	30.4	7.8	12.75	25.5	4500
				"	"	29.7	7.42	12.4	24.8	5000
				"	"	22.9	5.72	10.75	21.5	6000
				"	"	21.4	5.35	10.35	20.7	7000
				"	"	13.0	3.25	7.85	15.7	8000
				"	"	8.6	2.15	6.2	12.4	9000
				"	"	5.2	1.3	4.55	9.1	10000

REMARKS

* See Transformer Curve Sheet No. 20
This is a re-run for verification purposes of run recorded on Sheet No. 29.

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **29** Test No. **12** Sheet No. **65**

Amplifier Tube

Type **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	* f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	17.9a	4.47a	9.4	18.8	60
				"	"	20.4	5.1	10.05	20.1	100
				"	"	22.4	5.6	10.6	21.2	200
				"	"	23.3	5.82	10.85	21.7	300
				"	"	23.5	5.87	10.9	21.8	400
				"	"	23.7	5.92	10.95	21.9	500
				"	"	23.6	5.9	10.95	21.9	700
				"	"	23.7	5.92	10.95	21.9	1000
				"	"	24.0	6.0	11.0	22.0	1500
				"	"	25.3	6.37	11.35	22.7	2000
See Data Sheet										
No. 23				"	"	27.0	6.75	11.75	23.5	2500
and				"	"	29.4	7.35	12.35	24.7	3000
Calibration				"	"	28.7	7.17	12.15	24.3	3500
Curve				"	"	30.2	7.55	12.55	25.1	4000
Sheet				"	"	30.3	7.57	12.55	25.1	4500
No. 4				"	"	29.9	7.47	12.45	24.9	5000
				"	"	23.7	5.92	10.95	21.9	6000
				"	"	22.1	5.52	10.5	21.0	7000
				"	"	14.9	3.72	8.5	17.0	8000
				"	"	9.4	2.35	6.55	13.1	9000
				"	"	6.2	1.8	5.6	11.2	10000

REMARKS

* See Transformer Curve Sheet No. 23

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 10 Sheet No. 66

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B=90 volts; E_C=4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		*
				.325a	.5	18.0a	4.5 a	9.4	18.8	60
				"	"	21.0	5.25	10.2	20.4	100
				"	"	22.4	5.6	10.6	21.2	200
				"	"	22.4	5.6	10.6	21.2	300
				"	"	23.9	5.97	11.0	22.0	400
				"	"	23.2	5.8	10.8	21.6	500
				"	"	23.7	5.92	10.95	21.9	700
				"	"	24.4	6.1	11.1	22.2	1000
See Data Sheet				"	"	24.7	6.17	11.2	22.4	1200
No. 23				"	"	24.9	6.22	11.25	22.5	1500
and				"	"	26.7	6.67	11.65	23.3	2000
Calibration				"	"	27.0	6.75	11.75	23.5	2200
Curve				"	"	27.0	6.75	11.75	23.5	2500
Sheet				"	"	29.3	7.32	12.3	24.6	3000
No. 4				"	"	30.4	7.6	12.6	25.2	3500
				"	"	32.3	8.07	13.0	26.0	4000
				"	"	33.7	8.42	13.3	26.6	4500
				"	"	30.3	7.57	12.55	25.1	5000
				"	"	27.1	6.72	11.7	23.4	6000
				"	"	21.1	5.27	10.25	20.5	7000
				"	"	13.4	3.35	8.0	16.0	8000
				"	"	8.4	2.1	6.1	12.2	9000
				"	"	5.4	1.35	4.7	9.4	10000

REMARKS

* See Transformer Curve Sheet No. 22

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **46** Test No. **6** Sheet No. **67**

Amplifier Tube

Type **UX299** No. **1** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **3** volts

Calibration at 60 cycles: Input volts E (k=1)	Calibration at 60 cycles: Plate current in milliamperes I_p (k=)	Calibration at 60 cycles: Plate current in milliamperes I_p (k=1)	Input milliamperes I_p (k=)	Input milliamperes I_p (k=1)	Input equiv. volts E_1 (k=1)	Output milliamperes I_p (k=.25)	Output milliamperes I_p (k=1)	Output equiv. volts E_2 (k=1)	Voltage amplification E2/E1 E_a	* Frequency in cycles per second f
				.325a	.5	2.6a	.65a	2.85	5.7	60
				"	"	4.1	1.02	3.9	7.8	100
				"	"	6.2	1.55	5.05	10.1	200
				"	"	6.7	1.67	5.3	10.6	300
				"	"	7.0	1.75	5.5	11.0	400
				"	"	7.4	1.85	5.65	11.3	500
				"	"	7.6	1.9	5.8	11.6	700
				"	"	7.7	1.93	5.85	11.7	1000
				"	"	7.3	1.83	5.6	11.2	1200
See Data Sheet				"	"	7.0	1.75	5.5	11.0	1500
No. 23				"	"	6.9	1.72	5.4	10.8	2000
and				"	"	6.5	1.62	5.25	10.5	2200
Calibration				"	"	6.0	1.5	5.0	10.0	2500
Curve				"	"	5.3	1.32	4.6	9.2	3000
Sheet				"	"	4.8	1.2	4.3	8.6	3500
No. 4				"	"	4.1	1.02	4.0	8.0	4000
				"	"	3.4	.85	3.4	6.8	4500
				"	"	3.3	.83	3.3	6.6	5000
				"	"	3.0	.75	3.1	6.2	6000
				"	"	2.6	.65	2.75	5.5	7000
				"	"	2.2	.55	2.35	4.7	8000
				"	"	2.0	.5	2.0	4.0	9000
				"	"	1.6	.4	1.5	3.0	10000

REMARKS

* See Transformer Curve Sheet No. 7

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **29** Test No. **13** Sheet No. **68**

Amplifier Tube

Type **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **4.5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a	* f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	17.9a	4.47a	9.35	18.7	60
				"	"	18.2	4.55	9.45	18.9	100
				"	"	19.7	4.92	9.85	19.7	200
				"	"	20.0	5.0	9.95	19.9	300
				"	"	20.0	5.0	9.95	19.9	400
				"	"	20.7	5.17	10.1	20.2	500
				"	"	20.6	5.15	10.1	20.2	700
See Data Sheet				"	"	20.0	5.0	9.95	19.9	1000
No. 23				"						
and				"	"	21.0	5.25	10.2	20.4	1500
Calibration				"	"	21.3	5.32	10.3	20.6	2000
Curve										
Sheet				"	"	21.7	5.42	10.4	20.8	2500
No. 4				"	"	24.6	6.15	11.15	22.3	3000
				"	"	25.7	6.42	11.45	22.9	3500
				"	"	28.1	7.02	12.0	24.0	4000
				"	"	29.0	7.25	12.25	24.5	4500
				"	"	28.0	7.0	12.0	24.0	5000
				"	"	24.4	6.1	11.1	22.2	6000
				"	"	22.7	5.67	10.7	21.4	7000
				"	"	14.0	3.5	8.2	16.4	8000
				"	"	10.0	2.5	6.8	13.6	9000
				"	"	6.3	1.57	5.1	10.2	10000

REMARKS

* See Transformer Curve Sheet No. 22.

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 14 Sheet No. 69

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5.5 volts

VACUUM TUBE VOLTMETER									Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output				
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a*	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	18.0	4.5 a	9.4	18.8	60
				"	"	21.0	5.25	10.25	20.5	100
				"	"	22.0	5.5	10.5	21.0	200
				"	"	23.3	5.82	10.85	21.7	300
				"	"	23.7	5.92	10.95	21.9	400
				"	"	24.0	6.0	11.0	22.0	500
				"	"	23.9	5.97	11.0	22.0	700
				"	"	24.0	6.0	11.0	22.0	1000
				"	"	24.3	6.07	11.15	22.3	1200
				"	"	24.6	6.15	11.2	22.4	1500
See Data Sheet				"	"	25.1	6.27	11.3	22.6	2000
No. 23				"	"	26.1	6.52	11.55	23.1	2500
and				"	"	28.8	7.2	12.2	24.4	3000
Calibration				"	"	29.8	7.45	12.45	24.9	3500
Curve Sheet				"	"	32.2	8.05	13.0	26.0	4000
No. 4				"	"	33.6	8.4	13.3	26.6	4500
				"	"	31.4	7.85	12.8	25.6	5000
				"	"	24.0	6.0	11.0	22.0	6000
				"	"	23.0	5.75	10.75	21.5	7000
				"	"	15.0	3.75	8.5	17.0	8000
				"	"	9.3	2.32	6.5	13.0	9000
				"	"	6.0	1.5	5.0	10.0	10000

REMARKS

* See Transformer Curve Sheet No. 22

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 29 Test No. 5 Sheet No. 70

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B=135 volts; E_C= 9 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output				
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts	E2/E1	
E	I_p		I_p		E_1	I_p		E_2	E_a*	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	17.1	4.27a	9.15	18.3	60
				"	"	20.4	5.1	10.05	20.1	100
				"	"	21.4	5.35	10.35	20.7	200
				"	"	22.3	5.57	10.55	21.1	300
				"	"	21.7	5.42	10.45	20.9	400
				"	"	22.3	5.57	10.55	21.1	500
				"	"	22.2	5.55	10.55	21.1	700
See Data Sheet				"	"	23.4	5.85	10.85	21.7	1000
No. 23										
and				"	"	23.6	5.9	10.9	21.8	1500
Calibration				"	"	24.9	6.22	11.25	22.5	2000
Curve				"	"	25.3	6.32	11.35	22.7	2200
Sheet				"	"	26.4	6.6	11.6	23.2	2500
No. 4				"	"	28.3	7.07	12.05	24.1	3000
				"	"	31.1	7.77	12.75	25.5	3500
				"	"	33.1	8.27	13.2	26.4	4000
				"	"	34.4	8.6	13.45	26.9	4500
				"	"	33.6	8.4	13.3	26.6	5000
				"	"	28.2	7.05	12.05	24.1	6000
				"	"	24.0	6.0	11.0	22.0	7000
				"	"	16.5	4.12	8.95	17.9	8000
				"	"	9.5	2.37	6.55	13.1	9000
				"	"	6.0	1.5	5.0	10.0	10000

REMARKS

* See Transformer Curve Sheet No. 22

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **53** Test No. **1** Sheet No. **71**

Amplifier Tube

Type **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input			Output			$E2/E1$	
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	8.0a	2.00a	5.95	11.9	60
				"	"	14.7	3.67	8.4	16.8	100
				"	"	21.2	5.3	10.3	20.6	200
				"	"	22.3	5.57	10.55	21.1	300
				"	"	22.7	5.67	10.65	21.3	400
				"	"	23.0	5.75	10.75	21.5	500
				"	"	23.8	5.95	10.95	21.9	700
				"	"	24.2	6.05	11.05	22.1	1000
				"	"	23.5	5.87	10.85	21.7	1200
See Data Sheet				"	"	22.4	5.6	10.60	21.2	1500
No. 23				"	"	20.2	5.05	10.00	20.0	2000
and				"	"	18.9	4.97	9.90	19.8	2200
Calibration				"	"	18.3	4.57	9.50	19.0	2500
Curve				"	"	15.9	3.97	8.75	17.5	3000
Sheet No. 4				"	"	14.3	3.57	8.25	16.5	3500
				"	"	12.7	3.17	7.75	15.5	4000
				"	"	11.0	2.75	7.15	14.3	4500
				"	"	9.0	2.25	6.4	12.8	5000
				"	"	6.3	1.57	5.1	10.2	6000
				"	"	4.3	1.07	4.0	8.0	7000
				"	"	3.5	.87	3.5	7.0	8000
				"	"	2.8	.7	2.9	5.8	9000
				"	"	2.0	.5	2.1	4.2	10000

REMARKS

* See Transformer Curve Sheet No. 28

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **54** Test No. **1** Sheet No. **72**

Amplifier Tube

Type **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
			Input			Output			$E2/E1$	
Input volts	Plate current in milliamperes		milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k= .25	k=1	k=1		
				.325a	.5	6.8a	1.70a	5.4	10.8	60
				"	"	8.9	2.22	6.35	12.7	100
				"	"	9.3	2.32	6.5	13.0	200
				"	"	9.5	2.37	6.6	13.2	300
				"	"	9.8	2.45	6.7	13.4	400
				"	"	10.2	2.55	6.85	13.7	500
				"	"	10.5	2.62	6.95	13.9	700
See Data Sheet				"	"	10.4	2.6	6.9	13.8	1000
No. 23				"	"	10.4	2.6	6.9	13.8	1200
and				"	"	10.4	2.6	6.9	13.8	1500
Calibration				"	"	10.7	2.67	7.0	14.0	2000
Curve				"	"	9.8	2.45	6.7	13.4	2200
Sheet No. 4				"	"	9.6	2.4	6.6	13.2	2500
				"	"	9.3	2.32	6.5	13.0	3000
				"	"	9.2	2.3	6.45	12.9	3500
				"	"	9.0	2.25	6.4	12.8	4000
				"	"	9.0	2.25	6.4	12.8	4500
				"	"	8.0	2.0	5.95	11.9	5000
				"	"	6.0	1.5	5.0	10.0	6000
				"	"	4.8	1.2	4.3	8.6	7000
				"	"	3.8	.95	3.7	7.4	8000
				"	"	2.5	.62	2.65	5.3	9000
				"	"	1.8	.45	1.9	3.8	10000

REMARKS

* See Transformer Sheet No.28

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 54 Test No. 15 Sheet No. 73

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B=90 volts; E_C=4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	6.2	1.55	5.1	10.2	60
				"	"	8.2	2.05	6.0	12.0	100
				"	"	9.1	2.275	6.4	12.8	200
				"	"	9.5	2.37	6.6	13.2	300
				"	"	9.8	2.45	6.7	13.4	400
				"	"	9.9	2.47	6.75	13.5	500
				"	"	10.0	2.5	6.8	13.6	700
				"	"	10.0	2.5	6.8	13.6	1000
	See Data Sheet			"	"	9.5	2.37	6.6	13.2	1200
	No. 23			"	"	8.6	2.25	6.35	12.7	1500
	and			"	"	8.3	2.07	6.1	12.2	2000
	Calibration			"	"	7.8	1.95	5.85	11.7	2200
	Curve Sheet			"	"	7.5	1.87	5.7	11.4	2500
	No. 4			"	"	7.0	1.75	5.5	11.0	3000
				"	"	6.0	1.5	5.0	10.0	3500
				"	"	4.5	1.12	4.15	8.3	4000
				"	"	4.0	1.0	3.9	7.8	4500
				"	"	3.2	.8	3.25	6.5	5000
				"	"	2.0	.5	2.0	4.0	6000
				"	"	1.8	.45	1.9	3.8	7000
				"	"	1.4	.35	1.0	2.0	8000
				"	"	1.3	.32	.8	1.6	9000
				"	"	1.3	.32	.8	1.6	10000

REMARKS

* See Transformer Curve Sheet No. 28

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 53   Test No. 15   Sheet No. 74

Amplifier Tube

Type **CX301A** No. 4   Voltages:— E_B= 90 volts; E_C=4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5a	7.6a	1.9	5.8	11.6	60
				"	"	12.5	3.12	7.65	15.3	100
				"	"	17.2	4.3	9.2	18.4	200
				"	"	18.8	4.7	9.6	19.2	300
				"	"	19.5	4.87	9.8	19.6	400
				"	"	18.0	4.5	9.4	18.8	500
				"	"	17.8	4.45	9.35	18.7	700
				"	"	15.0	3.75	8.5	17.0	1000
				"	"	13.5	3.37	8.0	16.0	1200
				"	"	12.0	3.0	7.5	15.0	1500
				"	"	9.4	2.35	6.55	13.1	2000
	See Data Sheet			"	"	8.2	2.05	6.05	12.1	2200
	No.23			"	"	7.0	1.75	5.5	11.0	2500
	and			"	"					2700
	Calibration Curve			"	"	5.8	1.45	4.9	9.8	3000
	Sheet No.4			"	"	4.4	1.1	4.1	8.2	3500
				"	"	3.8	.95	3.7	7.4	4000
				"	"	3.0	.75	3.0	6.0	4500
				"	"	2.6	.65	2.75	5.5	5000
				"	"	2.0	.5	2.0	4.0	6000
				"	"	1.7	.42	1.7	3.4	7000
				"	"	1.5	.37	1.3	2.6	8000
				"	"	1.4	.35	1.0	2.0	9000
				"	"	1.2	.3			10000

REMARKS

* See Transformer Curve Sheet No.28

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 2 Test No. 10 Sheet No. 75

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input			Output				
			milliamperes		equiv. volts	milliamperes		equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=25	k=1	k=1		
				.325a	.5	11.3a	2.82a	7.25	14.5	60
				"	"	15.0	3.75	8.5	17.0	100
				"	"	16.3	4.07	8.95	17.9	200
				"	"	18.7	4.67	9.55	19.1	300
				"	"	18.9	4.72	9.65	19.3	400
				"	"	19.0	4.75	9.7	19.4	500
				"	"	19.2	4.80	9.75	19.5	700
				"	"	19.2	4.80	9.75	19.5	1000
				"	"	19.0	4.75	9.7	19.4	1500
				"	"	18.4	4.60	9.5	19.0	2000
See Data Sheet				"	"	17.8	4.45	9.35	18.7	2200
No. 23 and				"	"	16.0	4.00	8.8	17.6	2500
Calibration Curve				"	"	14.5	3.62	8.35	16.7	3000
Sheet No. 4				"	"	11.4	2.85	7.3	14.6	3500
				"	"	8.9	2.22	6.35	12.7	4000
				"	"	7.3	1.82	5.6	11.2	4500
				"	"	5.5	1.37	4.75	9.5	5000
				"	"	3.5	.87	3.45	7.9	6000
				"	"	2.4	.60	2.5	5.0	7000
				"	"	1.9	.47	1.95	3.9	8000
				"	"	1.5	.37	1.35	2.7	9000
				"	"	1.2	.30	0.0	0.0	10000

REMARKS

° See Transformer Curve Sheet No. 2

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. **55** Test No. **1** Sheet No. **76**

Amplifier Tube

Type **CX301A** No. **4** Voltages:— E_B= **90** volts; E_C= **4.5** volts; E_F= **5** volts

VACUUM TUBE VOLTMETER										Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.								
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts			
E	I_p		I_p		E_1	I_p		E_2		E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1			
				.325a	.5	15.3a	3.82a	8.55		17.1	60
				"	"	17.0	4.25	9.1		18.2	100
				"	"	20.3	5.07	10.05		20.1	200
				"	"	19.7	4.92	9.85		19.7	300
				"	"	20.4	5.10	10.05		20.1	400
				"	"	20.1	5.02	9.95		19.9	500
				"	"	20.6	5.15	10.1		20.2	700
				"	"	19.8	4.95	9.9		19.8	1000
				"	"	19.0	4.75	9.7		19.4	1200
				"	"	18.3	4.57	9.5		19.0	1500
				"	"	18.0	4.50	9.4		18.8	2000
See Data Sheet				"	"	18.2	4.55	9.5		19.0	2200
No. 23				"	"	18.2	4.55	9.45		18.9	2500
and				"	"	17.2	4.30	9.2		18.4	3000
Calibration				"	"	15.3	3.82	8.55		17.1	3500
Curve				"	"	15.0	3.75	8.5		17.0	4000
Sheet				"	"	14.0	3.50	8.2		16.4	4500
No. 4				"	"	13.1	3.27	7.85		15.7	5000
				"	"	12.0	3.00	7.5		15.0	6000
				"	"	10.8	2.70	7.1		14.2	7000
				"	"	9.0	2.25	6.35		12.7	8000
				"	"	7.2	1.80	5.6		11.2	9000
				"	"	6.1	1.52	5.0		10.0	10000

REMARKS

* See Transformer Curve Sheet No. 13

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 56 Test No. 1 Sheet No. 77

Amplifier Tube

Type CX301A No. 4 . Voltages:— E_B= 90 volts; E_C=4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER										Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.								
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts			
E	I_p		I_p		E_1	I_p		E_2		E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1			
				.325a	.5	16.3a	4.07a	8.9		17.8	60
				"	"	24.8	6.20	11.2		22.4	100
				"	"	32.7	8.17	13.1		26.2	200
				"	"	33.0	8.25	13.15		26.3	300
				"	"	33.2	8.30	13.2		26.4	400
				"	"	33.4	8.35	13.25		26.5	500
				"	"	33.6	8.40	13.3		26.6	700
See Data Sheet				"	"	33.3	8.32	13.2		26.4	1000
No. 23				"	"	30.8	7.70	12.7		25.4	1200
and				"	"	30.4	7.60	12.6		25.2	1500
Calibration				"	"	26.7	6.67	11.65		23.3	2000
Curve				"	"	25.0	6.25	11.25		22.5	2200
Sheet				"	"	22.8	5.70	10.7		21.4	2500
No. 4				"	"	21.0	5.25	10.2		20.4	3000
				"	"	17.0	4.25	9.15		18.3	3500
				"	"	15.6	3.90	8.7		17.4	4000
				"	"	13.4	3.35	8.0		16.0	4500
				"	"	12.3	3.07	7.6		15.2	5000
				"	"	9.3	2.32	6.5		13.0	6000
				"	"	7.8	1.95	5.85		11.7	7000
				"	"	6.4	1.6	5.2		10.4	8000
				"	"	5.2	1.3	4.6		9.2	9000
				"	"	4.8	1.2	4.3		8.6	10000

REMARKS

* See Transformer Curve Sheet No. 13

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 57° Test No. 1 Sheet No. 78

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER										Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							$E2/E1$	
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts			
E	I_p		I_p		E_1	I_p		E_2		E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1			
				.325a	.5	5.1a	1.27a	4.5		9.0	60
				"	"	9.0	2.25	6.4		12.8	100
				"	"	15.6	3.9	8.7		17.4	200
				"	"	17.0	4.25	9.1		18.2	300
				"	"	18.0	4.5	9.4		18.8	400
				"	"	19.3	4.82	9.75		19.5	500
				"	"	19.6	4.90	9.8		19.6	700
				"	"	18.8	4.75	9.65		19.3	1000
See Data Sheet				"	"	18.2	4.55	9.45		18.9	1200
No. 23				"	"	17.9	4.49	9.4		18.8	1500
and				"	"	16.6	4.15	8.95		17.9	2000
Calibration				"	"	15.3	3.82	8.6		17.3	2200
Curve				"	"	15.0	3.75	8.5		17.0	2500
Sheet				"	"	13.3	3.32	7.95		15.9	3000
No. 4				"	"	12.7	3.17	7.7		15.4	3500
				"	"	10.7	2.67	6.95		13.9	4000
				"	"	9.8	2.45	6.7		13.4	4500
				"	"	9.2	2.3	6.45		12.9	5000
				"	"	7.8	1.95	5.85		11.7	6000
				"	"	6.7	1.67	5.3		10.6	7000
				"	"	5.0	1.25	4.4		8.8	8000
				"	"	4.7	1.17	4.2		8.4	9000
				"	"	3.6	.9	3.55		7.1	10000

REMARKS

* See Transformer Curve Sheet No. 5

° Connections made from exterior of catacomb.

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 58 Test No. 1 Sheet No. 79

Amplifier Tube

Type CX301A No. 4 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	7.9a	1.97a	5.9	11.8	60
				"	"	10.9	2.75	7.15	14.3	100
				"	"	14.0	3.5	8.2	16.4	200
				"	"	15.3	3.82	8.6	17.2	300
				"	"	16.3	4.07	8.9	17.8	400
				"	"	17.2	4.3	9.15	18.3	500
See Data Sheet				"	"	17.9	4.47	9.35	18.7	700
No. 23				"	"	17.8	4.45	9.35	18.7	1000
and				"	"	18.0	4.5	9.4	18.8	1200
Calibration				"	"	17.8	4.45	9.35	18.7	1500
Curve				"	"	18.7	4.67	9.6	19.2	2000
Sheet				"	"	19.7	4.92	9.85	19.7	2200
No. 4				"	"	20.5	5.12	10.1	20.2	2500
				"	"	21.8	5.45	10.45	20.9	3000
				"	"	22.3	5.57	10.55	21.1	3500
				"	"	21.5	5.37	10.35	20.7	4000
				"	"	20.5	5.12	10.1	20.2	4500
				"	"	18.5	4.62	9.55	19.1	5000
				"	"	12.1	3.02	7.55	15.1	6000
				"	"	7.8	1.95	5.85	11.7	7000
				"	"	4.4	1.10	4.1	8.2	8000
				"	"	3.0	.75	3.1	6.2	9000
				"	"	2.2	.55	2.35	4.7	10000

REMARKS

* See Transformer Curve Sheet No. 27

VOLTAGE AMPLIFICATION TEST DATA SHEET

193

Transformer No. 58 Test No. 1a Sheet No. 80

Amplifier Tube

Type CX301A No. 3 Voltages:— E_B= 90 volts; E_C= 4.5 volts; E_F= 5 volts

VACUUM TUBE VOLTMETER									Voltage amplification $E2/E1$	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.							
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a *	f
k=1	k=	k=1	k=	k=1	k=1	k=.25	k=1	k=1		
				.325a	.5	5.0a	1.25a	4.45	8.9	60
				"	"	8.3	2.07	6.05	12.1	100
				"	"	15.0	3.75	8.5	17.0	200
				"	"	17.7	4.42	9.3	18.6	300
				"	"	18.8	4.7	9.6	19.2	400
				"	"	20.2	5.05	10.0	20.0	500
				"	"	20.8	5.2	10.15	20.3	700
				"	"	21.0	5.25	10.2	20.4	1000
See Data Sheet				"	"	20.3	5.07	10.05	20.1	1200
No. 23				"	"	20.0	5.0	9.9	19.8	1500
and				"	"	19.6	4.9	9.85	19.7	2000
Calibration				"	"	18.9	4.75	9.7	19.4	2200
Curve				"	"	17.6	4.4	9.3	18.6	2500
Sheet				"	"	16.3	4.07	8.9	17.8	3000
No. 4				"	"	15.3	3.82	8.6	17.2	3500
				"	"	14.0	3.5	8.2	16.4	4000
				"	"	12.7	3.17	7.75	15.5	4500
				"	"	11.6	2.9	7.35	14.7	5000
				"	"	8.5	2.12	6.2	12.4	6000
				"	"	6.4	1.6	5.15	10.3	7000
				"	"	4.8	1.2	4.3	8.6	8000
				"	"	3.4	.85	3.45	6.9	9000
				"	"	2.7	.67	2.8	5.6	10000

REMARKS

* See Transformer Curve Sheet No. 27

VOLTAGE AMPLIFICATION TEST DATA SHEET

Transformer No. 59 Test No. 1 Sheet No. 81

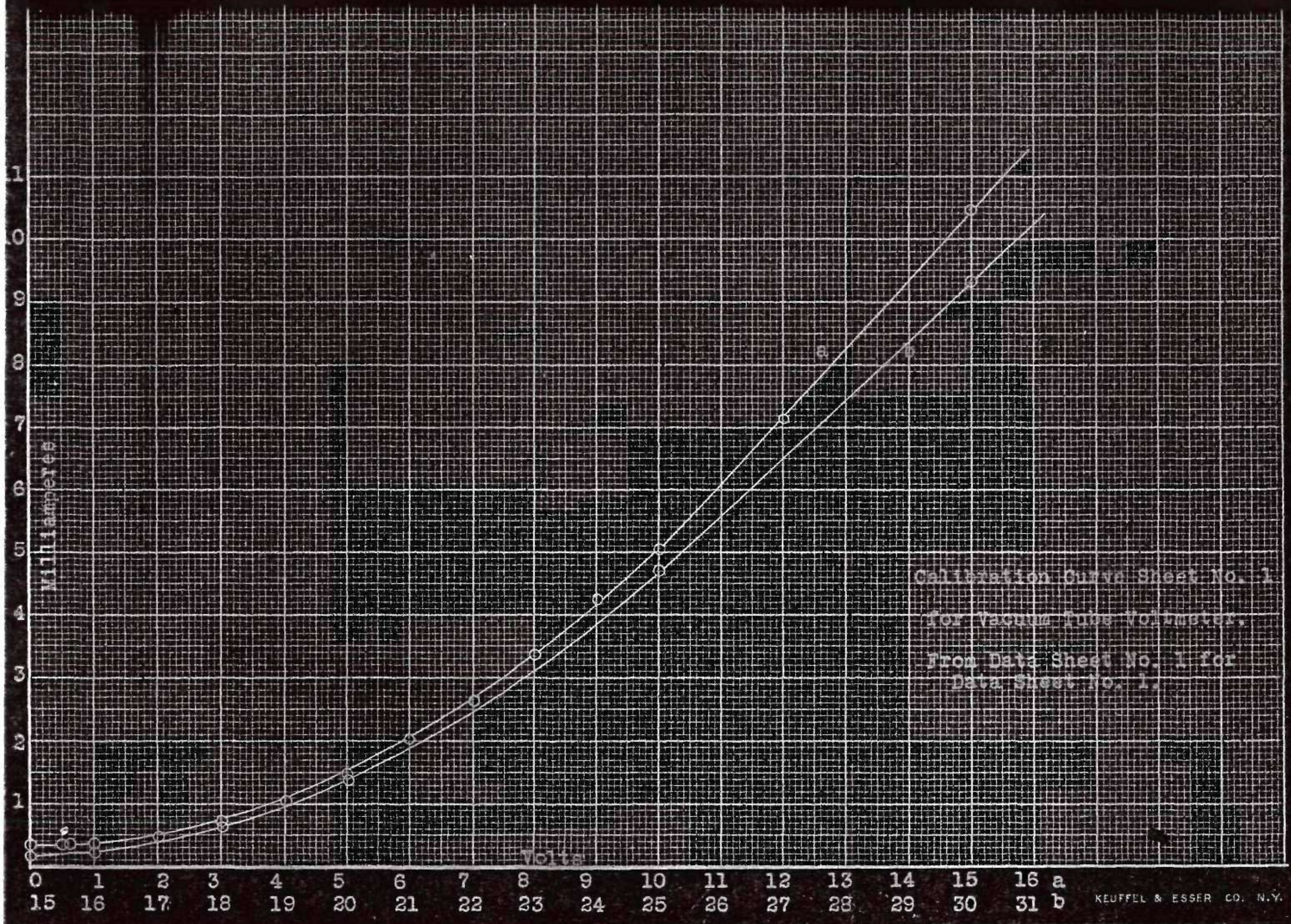
Amplifier Tube

Type CX301A No. 4 Voltages:— $E_B = 90$ volts; $-E_C = 4.5$ volts; $E_F = 5$ volts

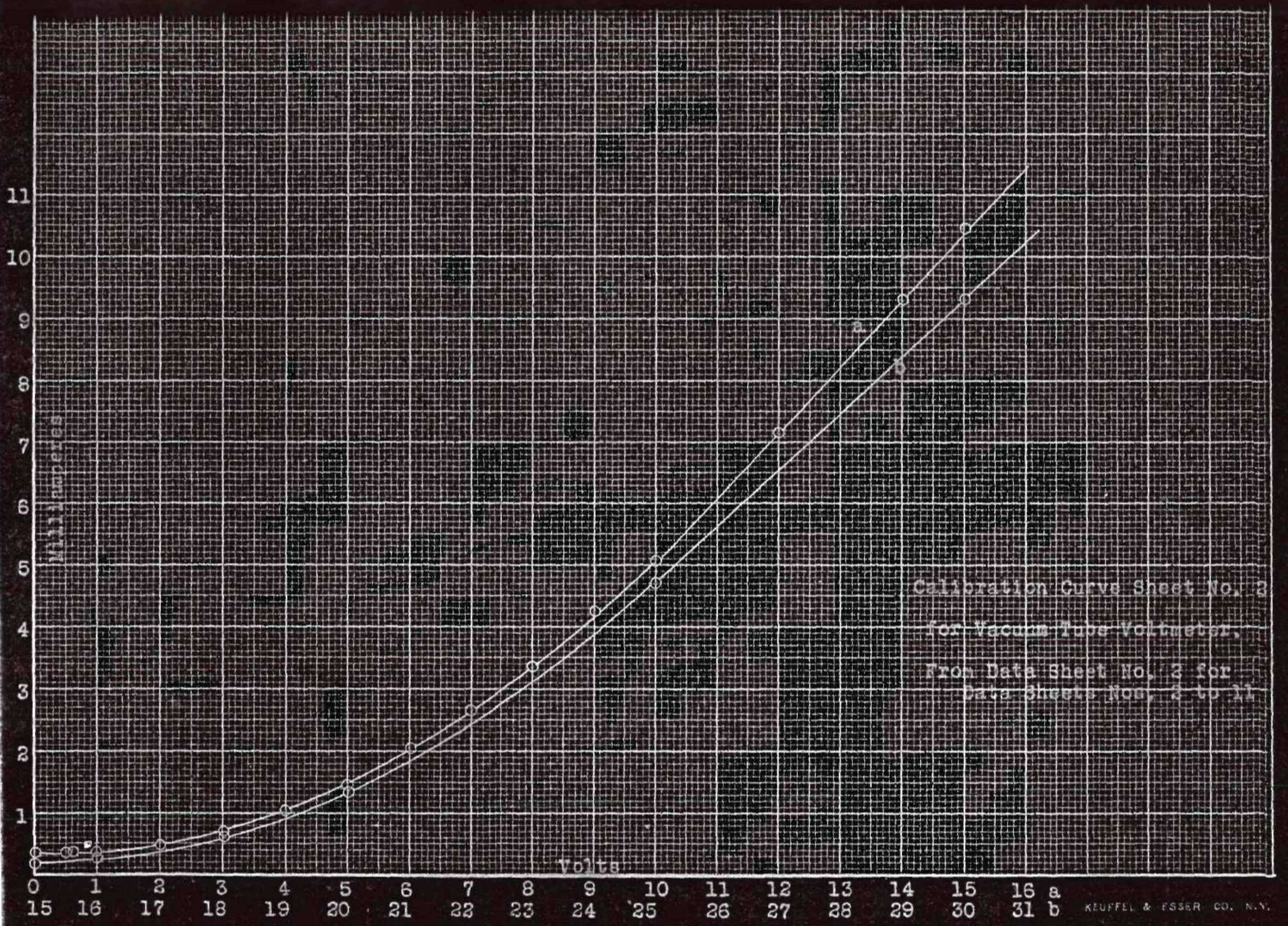
VACUUM TUBE VOLTMETER									Voltage amplification	Frequency in cycles per second
Calibration at 60 cycles			Reading for the amplifier at a given frequency f.						$E2/E1$	
Input volts	Plate current in milliamperes		Input milliamperes		Input equiv. volts	Output milliamperes		Output equiv. volts		
E	I_p		I_p		E_1	I_p		E_2	E_a °	f
k=1	k=	k=1	k=	k=1	k=1	k=25	k=1	k=1		
				.325a	.5	1.5a	.37a	1.2	2.4	60
				"	"	2.1	.52	2.2	4.4	100
				"	"	6.0	1.5	5.0	10.0	200
				"	"	12.0	3.0	7.5	15.0	300
				"	"	16.8	4.2	9.05	18.1	400
				"	"	21.2	5.3	10.3	20.6	500
				"	"	31.5	7.87	12.85	25.7	700
				"	"	37.7	9.42	14.15	28.3	1000
				"	"	37.2	9.3	14.05	28.1	1200
				"	"	33.0	8.25	13.15	26.3	1500
See	Data Sheet			"	"	24.2	6.05	11.05	22.1	2000
	No. 23			"	"	20.8	5.2	10.15	20.3	2200
	and			"	"	16.5	4.12	8.95	17.9	2500
Calibration				"	"	12.5	3.12	7.65	15.3	3000
	Curve			"	"	9.5	2.37	6.6	13.2	3500
	Sheet			"	"	8.7	2.17	6.25	12.5	4000
	No. 4			"	"	6.3	1.57	5.1	10.2	4500
				"	"	5.5	1.37	4.7	9.4	5000
				"	"	4.7	1.17	4.25	8.5	6000
				"	"	3.5	.87	3.5	7.0	7000
				"	"	2.8	.7	2.95	5.9	8000
				"	"	2.2	.55	2.35	4.7	9000
				"	"	2.0	.5	2.1	4.2	10000

REMARKS

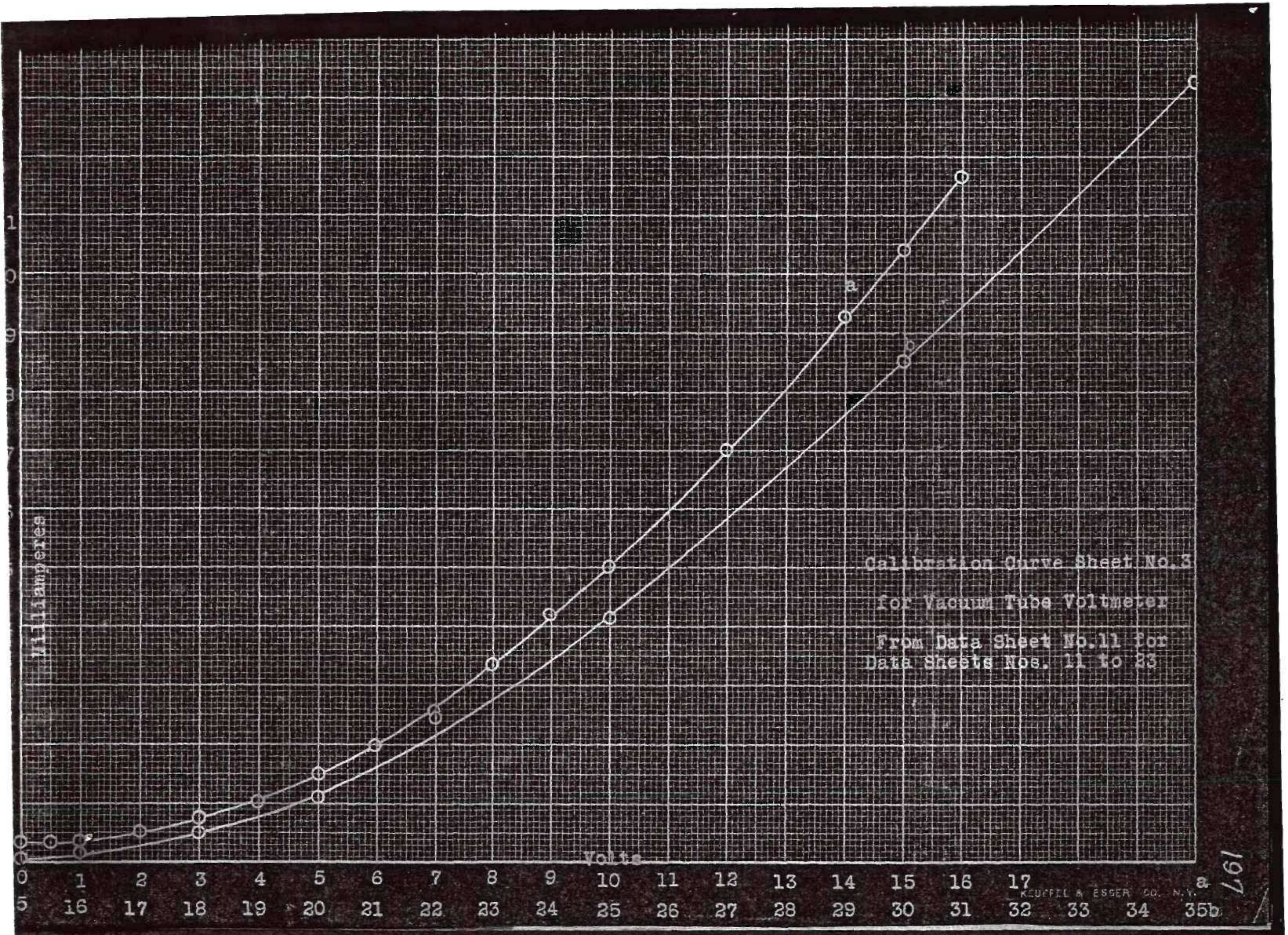
° See Transformer Curve Sheet No. 30

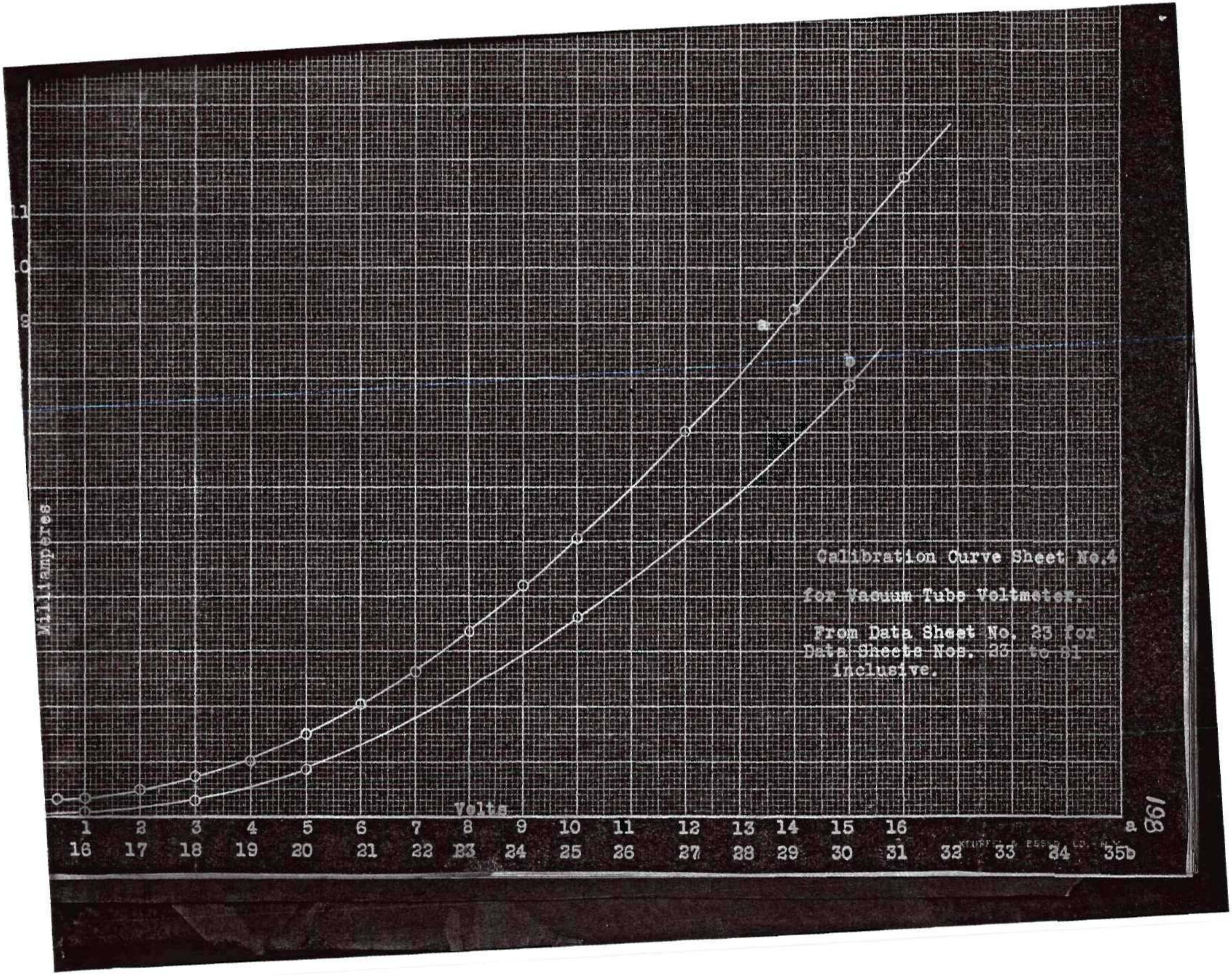


Calibration Curve Sheet No. 1
for Vacuum Tube Voltmeter.
From Data Sheet No. 1 for
Data Sheet No. 1.
Milliamperes
Volts
a
b
KEUFFEL & ESSER CO. N.Y.



Milliamperes
11
10
9
8
7
6
5
4
3
2
1
Volts
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 a
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 b
a
b
Calibration Curve Sheet No. 2
for Vacuum Tube Voltmeter.
From Data Sheet No. 2 for
Data Sheets Nos. 2 to 11
KEUFFEL & ESSER CO. N.Y.


Calibration Curve Sheet No.3
for Vacuum Tube Voltmeter
From Data Sheet No.11 for
Data Sheets Nos. 11 to 23
Milliamperes
Volts
a
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 a
5 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35b
KEUFFEL & ESSER CO. N.Y.


Milliamperes
9
10
11
Volts
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 a
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35b
a
b
Calibration Curve Sheet No.4
for Vacuum Tube Voltmeter.
From Data Sheet No. 23 for
Data Sheets Nos. 23 to 31
inclusive.

Summary of Data Sheets

Data Sheet No.	Transformer No.	Test No.	Transformer Curve Sheet No.
1	1	1	1
2	4	1	4
3	3	1	3
4	2	1	2
5	5	1	3
6	6	1	6
7	7	1	7
8	8	1	8
9	9	1	9
10	10	1	10
11	11	1	11
12	12	1	11
13	13	1	7
14	14	1	14
15	15	1	12
16	16	1	13
17	17	1	1
18	18	1	2
19	19	1	15
20	20	1	15
21	21	1	1
22	22	1	16
23	23	1	17
24	24	1	17

Summary of Data Sheets

(Continued)

25	25	1	17
26	26	1	18
27	27	1	19
28	28	1	18
29	29	1	20
30	30	1	20
31	29	1	20,21,22,23
32	29	2	21
33	29	3	21
34	29	4	21
35	31	1	1
36	32	1	15
37	33	1	12
38	34	1	5
39	35	1	2
40	36	1	9
41	37	1	9
42	38	1	9
43	39	1	9
44	40	1	14
45	41	1	14
46	42	1	2
47	43	1	29
48	44	1	5
49	45	1	25

Summary of Data Sheets

(Continued)

50	46	1	7
51	47	1	7
52	29	1b	23
53	29	6	23
54	29	6a	23
55	29	9	22
56	48	1	24
57	49	1	24
58	50	1	26
59	51	1	26
60	52	1	27
61	29	7	21
62	29	8	21
63	29	11	22
64	29	1	20
65	29	12	22
66	29	10	22
67	46	6	7
68	29	13	22
69	29	14	22
70	29	5	21
71	53	1	28
72	54	1	28
73	54	15	28
74	53	15	28

Summary of Data Sheets

(Continued)

75	2	10	2
76	55	1	13
77	56	1	13
78	57	1	5
79	58	1	27
80	58	1a	27
81	59	1	30

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